GEOLOGICAL SURVEY OF GEORGIA

S. W. McCALLIE, State Geologist

BULLETIN NO. 40

PETROLEUM
AND
NATURAL GAS POSSIBILITIES
IN
GEORGIA

BY

T. M. PRETTYMAN and H. S. CAVE

Assistant State Geologists

1923

BYRD PRINTING COMPANY

ATLANTA, GA.

THE ADVISORY BOARD

OF THE

Geological Survey of Georgia

IN THE YEAR 1923

(Ex-Officio)
His Excellency, Thomas W. Hardwick

Governor of Georgia
President of the Board

Hon. S. G. McLENDON ________________Secretary of State
Hon. W. J. SPEER ________________________ State Treasurer
Hon. W. A. WRIGHT _________________ Comptroller-General
Hon. GEORGE M. NAPIER ____________Attorney-General
Hon. J. J. BROWN __________ Commissioner of Agriculture
Hon. M. M. PARKS ______ Commissioner of Public Schools

LETTER OF TRANSMITTAL

GEOLOGICAL SURVEY OF GEORGIA,

ATLANTA, June 1, 1923.

To His Excellency, THOS. W. HARDWICK, *Governor, and President of the Advisory Board of the Geological Survey of Georgia.*

SIR: I have the honor to transmit herewith the report on the Possibilities of Petroleum and Natural Gas Production in Georgia, to be published as Bulletin No. 40 of this survey.

Very respectfully,

S. W. MCCALLIE,
State Geologist.

CONTENTS

CONTENTS--Continued

CONTENTS—Continued

ILLUSTRATIONS

PLATES

FIGURES

MAPS

POSSIBILITIES OF PETROLEUM AND NATURAL GAS PRODUCTION IN GEORGIA

INTRODUCTION

This report is devoted to a presentation of the data relative to the possibilities of petroleum and natural gas production in Georgia. In order that the subject may be more readily understood by the layman the writers have attempted to outline a few major principles of general geology, and have added brief statements regarding the nature of petroleum and natural gas, their origin, and mode of accumulation.

The data embraced within this report have been gathered from many sources. The account of the physiography, with only slight modifications, has been taken from the United States Geological Survey Water-Supply Paper 341 and from bulletin 15 of the State Survey. To these data has been added material collected in the field. The account of the geology has been in considerable part taken from the publications of L. W. Stephenson, C. W. Cooke, T. W. Vaughan, E. W. Berry, Otto Veatch, and H. K. Shearer, and in part based on field work of the writers. The section on "general geologic principles" and the section on "general considerations relative to petroleum and natural gas" have been compiled from the works of Pirsson and Shuchert, Chamberlin and Salisbury, Johnson and Huntley, W. H. Emmons, Dorsey Hager, David T. Day, and others.

The field work upon which this report is based was done during the seasons of 1921 and 1922. Practically the whole of the time spent in the field was in the Coastal Plain area, with only a very small part spent in that portion of the State north of the Fall line.

The authors express their thanks to C. W. Cooke and L. W. Stephenson, both of the United States Geological Survey, for the valuable aid and advice given by them. Thanks are likewise due to J. F. Wooten of Eastman, Ga., and to Robert Murray of Lumber City, Ga., for valuable well logs. Thanks are also given to W. T. Thom, Jr., of the United States Geological Survey, for his criticism of the manuscript and for valuable suggestions offered by him. It is impossible to state here the names of the numerous other persons who have contributed material used in this bulletin. In every case the writers have attempted to indicate the source of all such data. For these data they are grateful, and they also wish to express their appreciation of the interest and ready response shown by many citizens of the State.

GENERAL GEOLOGICAL PRINCIPLES

A study of the petroleum and oil possibilities of any area is essentially a problem of geology, and must be based upon certain fundamental geologic principles. These principles are mainly in the nature of earth processes, which have been going on since the earlier periods of geologic history and will continue indefinitely. They constitute the fulfillment of natural laws, which are only partly understood. Of these grand processes of nature, four are of especial interest: (1) Erosion and deposition; (2) earth movements; (3) the alteration of rocks; (4) animal and vegetable life.

EROSION AND DEPOSITION

Nearly all land masses are gradually being eroded or worn away. Mainly through the agency of rain and wind surface material is carried to the streams, which in turn transport their burden to the oceans, where it is deposited on the sea bottom. Thus erosion and deposition are complementary processes. Much of the transported material is carried as mechanically suspended solid matter, but the amount of dissolved matter carried in solution is also great.

The rate at which land surfaces are lowered by erosion is largely dependent upon the steepness of surface slope, the amount of rain and wind, and the tendency of the surface material to disintegrate and decompose into fine particles that may be easily moved. The sum of these factors generally determines the rate of erosion.[1]

Deposition of suspended matter is largely governed by current velocities. The swifter the current the larger the size of particles that can be carried. As currents decrease in velocity the coarser particles are dropped first and the deposits are graded according to size. As marine currents are usually swifter near ocean shores, sand and other coarse material is usually deposited near the shore line, and the finer material is carried farther out to sea. Very fine particles, which would normally remain in suspension for a long time, tend to coagulate through the agency of the salinity of sea water and sink to the bottom.

Dissolved matter, such as lime, is precipitated from solution under various favorable physical and chemical conditions. Bacteria are known to play an important part here. More highly soluble constituents, such as ordinary salt, remain in solution and cause the salinity of ocean water.

The transporting power of wind is an important factor in erosion and deposition. Fine particles of solid matter are carried great distances in the air.

The final result of erosion and deposition would be the leveling of all land masses approximately down to sea level, with the corresponding transfer of material to the oceans. The system would then probably approach a state of equilibrium were it not for the fact that movements of the earth's surface disturb the nicely adjusted balance.

EARTH MOVEMENTS

The surface of the earth is probably never entirely stationary. Practically every region that has been studied shows evidence of

[1] The rate of erosion of the Coastal Plain of Georgia, as estimated by Dole and Stabler, is approximately one foot in 8760 years. See Volume II, Report of National Conservation Commission, Senate Document No. 676, 1919.

repeated upward and downward movements, relative to other areas. Usually the rate of motion is very slow, extending over vast periods of time, but it is sometimes very rapid. Movements may be of regional extent, affecting many hundred thousand square miles of territory, or they may be localized within a very small area, of perhaps a fraction of one square mile. There is also great variation in the magnitude of vertical displacement, ranging probably from a few inches up to several miles.

Of the theories which have been advanced regarding the cause of earth movements, contraction due mainly to cooling is regarded as the most important. Internal heat effects and overloading of areas due to deposition are also considered important.

Earthquakes and volcanic activity sometimes accompany movements. The former are generally considered to be caused by readjustment along lines of weakness, and the latter to be caused by heat effects.

We have strong evidence that the interior of the earth is very hot, the temperature increasing with depth, but no one knows just how hot it is at extreme depth, neither is it known whether or not the material there is molten. There is however, evidence indicating that the whole earth was once molten. This could very well explain the high temperatures known to exist within the earth today.

All earth movements, whatever their cause may be, tend to buckle the horizontal beds into folds, which are sometimes very gentle, with only slight deviation from the horizontal, but at times the folding becomes so intense as to tilt the beds to a vertical position or even to overturn them. Beds which are brittle, and consequently easily broken, are often fractured by only gentle folding, while tougher material may be intensely deformed without breaking.

ALTERATION OF ROCKS

The material of which the earth is composed is ever-changing.

Chemical decomposition assisted by mechanical disintegration is persistently active in breaking down existing rocks and forming new types. Great pressures associated with folding and pressures due to weight of overlying material, together with other causes, bring about profound changes in the nature of rocks. Heat and the great element time are likewise effective.

Humidity of climate, with its associated abundance of vegetation in warm regions, resulting in the profuse liberation of organic acids in the ground water, is perhaps the most potent factor in rock alteration near the surface. Here, too, the impact of moving rain water and of wind, each with its burden of solid particles, is felt by all exposed rocks. The freezing and thawing of water collected in small crevices exert intermittent expansive forces with disruptive effects, and the downward pull of gravity is ever present, searching out every weakness in rock support.

Rocks buried beyond the reach of these weathering agencies are correspondingly slow in their rate of alteration, but here the effects of greater pressures come into play. All ground waters contain a greater or less quantity of the active chemical reagents, such as oxygen and carbon dioxide gas, promoting decomposition. In general the rate of change is greater near the surface and decreases with depth.

CLASSIFICATION OF ROCKS

Types.—The term *rock* is applied to all solid material of which the earth is composed, whether it be compact, like granite, or unconsolidated, like loose sand.

Rocks are broadly classified with reference to origin into three types—igneous, sedimentary, and metamorphic.

Igneous rocks are those which have solidified from a molten condition caused by great heat within the earth. Volcanic lava and granite are good examples of this type.

Sedimentary rocks are those which have been laid down by water or wind through erosion and deposition. Limestone and sandstone are good examples of this type.

Metamorphic rocks are of either igneous or sedimentary origin, and have been profoundly changed by such agencies as pressure and heat. Gneiss and marble are good examples of this type, the former being derived from granite and the latter from limestone.

All known rocks may be placed in one of the above three classes. The total amount of rock of sedimentary origin is very small compared with that of igneous origin. The latter theoretically might be considered to extend to the centre of the earth, and all rock originally of igneous nature before erosion and deposition began. The sedimentary rocks are naturally found only as an outer coating of the earth, which, however, is known to reach a thickness of many thousand feet in some areas. A large portion of the earth's surface is covered with thin deposits of loose alteration products, like sand, clay, and ordinary soil, more or less mixed. The more uniform, and usually more compact, rocks in place lie beneath this surface mantle.

Igneous rocks generally occur in great irregularly shaped masses, while the sedimentary rocks are usually in distinct layers, which were more or less horizontal when deposited but often have been folded or broken by earth movements.

Mineral contents.—All rock may be seen, by the aid of the microscope or even by the unaided eye alone, to be an aggregate of relatively small particles. The substance of each particle has a definite chemical composition and distinct physical properties and is called a mineral. One, two, or more minerals may be present in the same rock. More than a thousand such minerals are known, but most of them are comparatively rare, and the great bulk of earth material is composed of less than twenty-five of these minerals.

Following is a tabulated list of sixteen of the more important minerals, showing their general chemical composition and physical nature:

Table showing properties of 16 common minerals.

Name	Chemical Nature	General description
Quartz	Oxide of Silicon.	Resembles glass.
Feldspar	Silicate of aluminum, etc.	Light colored, hard, distinct cleavage.
Hornblende	Complex silicate, usually of calcium, magnesium and iron.	Usually dark colored, often greenish, hard.
Pyroxene	Complex silicate, usually of calcium, magnesium and iron.	Usually dark, often greenish, hard.
Calcite	Calcium carbonate.	Light colored, moderate hardness, effervesces with acids.
Chlorite	Silicate of Aluminum and magnesium with combined water.	Greenish, splits readily into non-elastic thin leaves.
Kaolin (clay)	Silicate of aluminum with combined water.	Light colored if pure, soft, plastic when wet.
Dolomite	Carbonate of calcium and magnesium.	Light colored, moderately hard.
Gypsum	Calcium sulphate with combined water.	Light colored to transparent, soft.
Hematite	Iron oxide.	Red or brown, heavy.
Limonite	Oxide of iron with combined water.	Yellow or brown, heavy.
Magnetite	Oxide of iron.	Very dark, often black, hard, heavy.
Mica	Silicate of aluminum, etc.	Black to transparent. Splits into thin flexible sheets.
Serpentine	Silicate of magnesium with combined water.	Greenish, usually with light-colored streaks.
Talc	Magnesium silicate with combined water.	Light colored, often greenish, soft, feels greasy.
Siderite	Carbonate of iron.	Usually brown, heavy.

Of the sixteen common minerals tabulated above, quartz, feldspar, hornblende, and pyroxene are by far the most common, comprising probably three-fourths or more of all rocks.

Pirsson[1] shows the average rock to have the following elementary composition, indicating 87.46 per cent of all rock material as being composed of the four elements oxygen, silicon, aluminum, and iron.

Chemical Composition of the average rock.

	Per cent.
Oxygen	47.07
Silicon	28.06
Aluminum	7.90
Iron	4.43
Calcium	3.44
Magnesium	2.40
Sodium	2.43
Potassium	2.45
Hydrogen	.22
Titanium	.40
Carbon	.20
Chlorine	.07
Phosphorus	.11
Sulphur	.11
All other elements	.71
	100.00

Texture.—Igneous rocks which solidify at great depths beneath the surface cool slowly and are coarse grained, while those which come to or near the surface while still liquid cool rapidly and have a much finer texture. Very rapid cooling of rocks high in quartz content tends to produce a glassy texture.

Rocks are named according to their origin, the minerals of which they are composed, and their texture. In general there is a metamorphic rock corresponding to each igneous or sedimentary rock from which it was derived. Following is a list of several of the more common rocks of each of the three main classes. In this classification the texture of a rock is considered, being termed course grained if the individual grains are large enough to be readily distinguishable to the unaided eye.

[1]Pirsson, L. V., "Rocks and Rock Minerals," p. 18, 1915.

Table Showing Characters of some common rocks.

Name	Origin	Mineral composition, etc.	Texture
Granite	Igneous	Mainly quartz and feldspar.	Coarse grained.
Felsite	"	Light-colored minerals of such small grain as to be indistinguishable to eye alone.	Fine grained.
Syenite	"	Mainly feldspar.	Coarse grained.
Diorite	"	Mainly feldspar and hornblende.	" "
Gabbro	"	Mainly feldspar and pyroxene.	" "
Basalt	"	Black or nearly black minerals of such small grain as to be indistinguishable to the eye alone.	Fine grained.
Sandstone	Sedimentary	Grains usually more or less rounded, mainly of quartz.	Coarse grained.
Limestone	"	Appreciably high in calcite.	Variable.
Clay	"	Mainly kaolin or associated mineral similar to kaolin.	Fine grained.
Shale	"	Similar to clay or mud.	Fine grained, usually thinly laminated.
Slate	Metamorphic	Similar to clay from which it was derived.	Fine grained, splits into thin layers.
Gneiss	"	Similar to granite from which it was derived.	Coarse grained, foliated, with more or less tendency to split into layers.
Marble	"	Similar to pure limestone from which it was derived.	Coarse grained.

Most igneous rocks are hard and compact, but sedimentary rocks are usually softer and often only loosely consolidated. Sedimentary rocks contain many animal and vegetable remains. Limestone, sandstone, clay or shale, or some combination of these, are by far the most abundant types of sedimentary rocks, for earth material eroded and prepared for deposition will nearly always be converted into one of these materials. There is much greater diversity among igneous rocks and also among metamorphic rocks.

LIFE ON THE EARTH AND THE GEOLOGIC TIME TABLE

The earth is very, very old. Abundant evidence likewise points to the great antiquity of animal and vegetable life, in comparison with which the earliest record of human life is quite recent. The ancient remains of animal and vegetable organisms, buried in sedimentary rocks during their deposition, ages ago, which are abundantly preserved in these rocks, tell us a great deal about the past history of the earth. Igneous rocks, however, and their metamorphic derivatives never contain these remains.

It has been universally observed that certain forms of organisms are found in certain sedimentary rocks, while in the overlying beds, which are consequently younger in age, many of these forms fail to appear and new ones take their place. It is also found that when a form disappears it never reappears in the younger rocks, except in the rare cases of recurrent forms due to migration. Thus the sedimentary rocks deposited during each period of the past have characteristic organisms which serve to identify them as belonging to that period of deposition. These animal and vegetable remains are called fossils. Some are microscopic in size while others are larger than most present day forms. The more common forms are shellfish of the general nature of modern clams and oysters. Usually only the harder parts of the body, such as shell, bone, and teeth, are preserved. The original material of the fossils is sometimes entirely and often partly replaced by mineral matter, the form, however, being preserved.

Fossils from all parts of the globe have been studied, classified, and named. Rocks of similar age contain similar fossils in all parts of the world. In addition to the time significance of the fossils they reflect the conditions under which the organisms lived.

The rocks themselves, especially those of sedimentary origin, also give much information regarding the past. If certain results are produced by certain geologic processes today it is reasonable to assume that similar results were produced by similar processes in

the past. On this basis, with the results of the past before us, mainly in the form of the sedimentary record, we can tell a great deal about the conditions which must have produced the observed results. Thus by studying almost any sedimentary bed at any locality it is possible to determine with greater or less certainty the conditions under which the bed was formed, i. e., the approximate depth of water, its degree of salinity, clarity, temperature, and current conditions, its proximity to land, and the nature of the surface rocks, topography, and climate.

With data of these kinds diligently compiled from many parts of the world it has been possible to interpret the past history of the earth and to arrange a time table of past events. The divisions of this table are in terms of earth movements, and the associated erosion and deposition cycles, and each subdivision has its characteristic fossils whereby rocks anywhere in the world may be more or less definitely correlated, showing at what time the formation in question was deposited.

The record of earth events preserved in the rocks has been partly obliterated, however, through rock alteration and erosion, and there are gaps in the record wherever no sediments were deposited. Some of these breaks in the continuity of the record will no doubt be filled in as newly discovered data become available, but many of the gaps will remain, for the data necessary to bridge them are no doubt hopelessly buried beyond human reach.

The names of many of the time divisions are place names, referring to the place where beds belonging to that period of deposition were first studied and classified.

Following is the geologic time table used commonly throughout the Western Hemisphere. In the Eastern Hemisphere some different names and different subdivisons are employed in parts of the table, but the time significance of the characteristic fossils is universally constant. The divisions enumerated in the table have smaller subdivisions not shown, which vary in name and from one

area to another, but the rocks were deposited during the same general epoch. For example, Miocene time is represented in Georgia by the Alum Bluff formation, the Marks Head marl, and the Duplin marl, while in certain southern California areas the Miocene embraces the Vaqueros formation and the Modelo formation.

Geologic Time Table.

Era.	Period of System.	Epoch or Series.
Cenozoic	Quaternary	Recent Pleistocene
	Tertiary	Pliocene Miocene Oligocene Eocene
Mesozoic	Cretaceous	Upper Cretaceous Lower Cretaceous
	Jurassic Triassic	
Paleozoic	Carboniferous	Permian Pennsylvanian Mississippian
	Devonian Silurian Ordovician Cambrian	
Proterozoic	Algonkian Archean	

The age of any bed of rock or any event in earth history is referred to one of the divisions of the above table, fundamentally on the evidence of fossils. Geologic time is measured in terms of these divisions and not in years. For example, we would say that a certain bed of rock is of Eocene age or of Cretaceous age, as shown by fossils in the bed itself or in another bed with established time relations to the one under consideration.

The question of the age of the earth in terms of years has been asked many times but never answered in an entirely satisfactory manner. Several methods have been used in attacking this difficult problem.

Assuming that the earth was once molten, calculations have been made of the time required for it to cool to its present temperature.

Another method is based on the measurement of the rates at which sedimentary rocks are today being deposited and eroded, and comparing the results with the measured thicknesses of sediments of the various periods in the time table.

A third method is based on the comparatively recently determined fact that the element uranium, of its own accord, changes to radium, which in turn changes to lead, the transformations always taking place at fixed rates, which have been determined. Thus by measuring the amount of each of the above elements in a rock, and determining certain radioactive properties, the age of the rock may be calculated in years.

The results of these age calculations vary widely. The time which has elapsed since the deposition of the oldest known sedimentary rocks, that is, since early Archean time, is placed as short as a few million years in some calculations and as great as more than a billion years in others. The present tendency is to regard the last named method, that of the rate of transformation of elements, as the most accurate. This method indicates that more than a billion years have passed since the beginning of geologic time.

SUMMARY OF GEOLOGIC HISTORY

The sequence of past events, referred to the standard time table, presents an interesting story of the earth. Some of the major events of this story connected with the North American continent are briefly summarized in the following outline.

Pre-Archean time.—Pre-Archean history is extremely theoretic and deals largely with the origin of the earth and the changes which

took place before its present general form and nature were attained.

Numerous theories have been advanced regarding the origin of the earth. One of the most popular theories is that the sun was once surrounded by an extremely hot and rarefied gaseous material which revolved about the central mass. In the course of time the outer rarefied gas tended to segregate about localized nuclei as centres of concentration. As these segregations cooled they condensed into molten matter, which on further cooling solidified and formed the earth and other planets.

According to another and later theory, large masses of hot, gaseous matter were thrown off from the sun. Condensation and later solidification took place. Gravity and collision are supposed to have united the numerous small bodies into a few larger ones, resulting in the formation of the various planets, including the earth.

A long time interval probably elapsed between the formation of the earth and earliest known sedimentation.

Proterozoic era.—The Archean period marks the beginning of definitely recorded earth history. Rocks of this age are found throughout a large part of Canada, in portions of the Appalachian province, and in certain Rocky Mountain areas. These rocks are all metamorphic, having been derived from both igneous and sedimentary types. There is evidence of earth movements elevating the land and forming mountain chains, of erosion and deposition, and of the advance and retreat of seas, together with other natural processes which have been going on ever since, constantly changing the surface of the earth.

There is no proof of life in the Archean, but the presence of certain mineral deposits in rocks of this age could best be explained by life on the globe at that time. Metamorphism has so altered the rocks as to obliterate all life forms which may once have been present. The period closed with a general continental uplift pushing back the everchanging ocean shore lines.

Algonkian rocks are in many ways similar to the Archean. The latter have the same general distribution as the former, from which they

are often inseparable. The Lake Superior deposits of iron and copper belong to rocks of these two periods. The oldest recognizable remains of life are of Algonkian age. In most of these rocks, however, as in the Archean, alteration has destroyed all evidence of organisms which may have existed.

Paleozoic era.—The Paleozoic marks the earliest time of which we have abundant fossil remains of life. Many of these forms are rather advanced types, suggesting the antecedent life indicated in the earlier periods. The geologic record is much more complete subsequent to the beginning of the Paleozoic than in the older rocks. Some of the greatest known deposits of coal and petroleum are found in formations of this age, especially those of Carboniferous time, during which the climate was very warm and land surfaces swampy over a large part of the world, regardless of latitude. Throughout North America the general continental outline remained constant. Several areas, generally confined to the outer edges of the continent, remained persistently above water during the numerous shallow-sea invasions and retreats over vast inland areas. The Mississippi River drainage basin underwent submergence and emergence many times. Paleozoic time is marked by the great development of invertebrate animals, fishes, and fernlike plants. Life during the late Paleozoic was adapted to the warm, low, swampy conditions which generally prevailed.

The era closed with a general uplift forming the Appalachian Mountains, many times higher than their present-day remains, which are mere remnants of these giant ancestors, worn down and softened in contour by subsequent erosion.

Mesozoic era.—Mesozoic continental sea inundations were less widespread than during the Paleozoic. The Cretaceous sea, which was the most extensive of the era, connected the present Gulf of Mexico with the Arctic Ocean, dividing the continent into eastern and western portions. Climate during the early Mesozoic was generally arid.

Mesozoic life was characterized by the great number of huge reptiles, whose remains constitute the most spectacular forms of the museums of the world. These great animals, however, like other forms, became extinct when changes brought about new living conditions, and new forms appeared to take their place. The era saw the appearance of birds, flowering plants, and primitive mammals. Great quantities of petroleum are found in the late Mesozoic rocks. The Rocky Mountains were formed during a widespread uplift at the close of the era.

Cenozoic era.—Throughout Cenozoic time a greater part of the continent has maintained an elevation above sea level. Sea transgressions have taken place as in previous eras, but have covered relatively smaller portions of the land. The present land area is almost as large as the continental mass which has had a tendency to retain its identity throughout the ages, the invading seas having been relatively shallow and superficial.

Life during the Cenozoic has been characterized by the mammals, human life apparently being first recorded in the Pliocene. Parts of the Pleistocene were very cold, attended by glaciers covering a large part of Canada and extending as far south as Ohio. The Great Lakes were formed by these glaciers, which on melting have gradually receded northward. The present Arctic ice cap and some of the more southerly glaciers are apparently the remnants of the last Pleistocene ice sheets.

Conclusions.—In considering the general plan of things outlined in earth history one is forcibly impressed by certain general principles which become evident.

The vastness of geologic time cannot be comprehended by the human mind with its finite limitations, and the true perspective of earth events is lost.

The face of the earth appears to remain constant. The mountains, hills, plains, rivers, oceans, and other common physical features of the

earth are apparently everlasting, because they may only be observed throughout a relatively short period of time, but in reality the face of the earth is ever changing, in great cycles of events.

Life forms on the earth are continually changing as new living conditions arise.

The events of earth history proceed in an efficient and orderly fashion, in response to natural laws. These laws are not all perfectly known, but to the extent that they are understood we are able to interpret past geologic events.

GENERAL CONSIDERATIONS RELATIVE TO PETROLEUM AND NATURAL GAS

DEFINITIONS OF TERMS

The word petroleum means rock oil. It is the name applied to an inflammable mixture of oily hydrocarbons which comes from the earth through natural seepages or from flowing or pumped wells. The average petroleum consists of an intimate mixture of gasoline, kerosene, lubricating oils, and paraffin or asphalt or both, each of which contains numerous compounds of carbon and hydrogen.

Petroleum has been known, under various names, for many centuries. It was known to the early Persians, Greeks, and Romans under the name of naptha. The term bitumen was used by the Romans to cover all the natural occurring hydrocarbons which are now known under the terms of petroleum, maltha, and asphaltum or asphalt.

Asphaltum is the dark, solid to semi-solid residue left after the evaporation of the lighter constituents (gasoline, kerosene, etc.) of one class of petroleum.

Maltha is the name applied to the pasty, oily substance midway in consistency between petroleum and asphaltum.

Natural or rock gas is a gaseous mixture, usually combustible, and formed naturally in the earth. It is sometimes found is-

suing through natural openings, but is generally obtained by boring. Natural gas is quite commonly associated with both petroleum and coal.

USES OF PETROLEUM

The uses of petroleum and its products are many and varied. The main uses are for the generating of power, heat, and light, and for purposes of lubrication. The chief products of petroleum, ranked in order of total money value, are: (1) Gasoline; (2) kerosene; (3)fuel oils; (4) lubricants. There are, in addition, some three hundred or more miscellaneous products.

HISTORICAL NOTES

Petroleum, asphalt, and maltha have been known since earliest historic times. References to petroleum and allied substances are to be found in the Bible and in the early Greek and Latin literature. In the early days, and until relatively recent date, the petroleum and asphalt were obtained from seeps, springs, and dug pits.

Although petroleum has been exploited for a century or more in Alsace and Burma, by means of deep dug shafts, the modern technology of oil drilling had its principal developments in the Appalachian region of the United States and in the Petrolia region of Ontario, Canada. The rotary type of drill was developed in the Gulf Coast region of Texas.

In the United States, between the years 1840 and 1860 there was considerable activity in the distilling of oil from coal and shale. By the year 1860 there were more than fifty distilling companies in the United States. In 1854 a company was organized to drill for oil, but the company failed and no well was drilled. In August, 1859, the first oil well in the United States was drilled by Col. Edwin L. Drake, near Titusville, Pa., to a depth of 69½ feet. Since that date the oil industry has developed with great rapidity, until in 1921 there were produced in the United States alone 472,-

183,000[1] barrels of crude oil. In 1920 there were more than 400 refineries and approximately 30,000 miles of transportation pipe lines in the United States. Up to the end of 1920 the United States had produced 5,429,693,000[2] barrels of petroleum, or approximately 62 per cent of the world's total production.

GEOLOGIC DISTRIBUTION

The age of rocks producing oil or gas, or both, range from Cambrian to Recent. The Cambrian of New York has produced a small amount of gas and the Cambrian of Alberta, British Columbia, and Quebec, Canada, has produced a little petroleum. Probably the oldest formation that has been of real commercial importance as a producer is the Trenton limestone, of Ordovician age. Of the oil produced in the world approximately 55 to 60 per cent has come from rocks of Tertiary age, with the Paleozoic of the United States ranking next, followed by the rocks of Mesozoic age.

The following table, taken from Johnson and Huntley's "Oil and Gas Production," page 28, shows the relative importance of the major producing formations:

Order of Prominence[3]

Oil	Gas
(1) Tertiary	(1) Devonian
(2) Carboniferous	(2) Carboniferous
(3) Cretaceous	(3) Cretaceous
(4) Devonian	(4) Silurian
(5) Ordovician	(5) Ordovician
(6) Silurian	(6) Tertiary

Theoretically, the older the rocks the greater the proportion of gas to oil, but, due to the fact that the older rocks are normally more inaccessible, they do not actually produce the most gas.

---

1 U. S. Geological Survey Statistics.

2 Day, David T., "Handbook of the Petroleum Industry," Vol. I, pp. 324-325, 1922.

3 Rank for oil is on potential basis; rank for gas on present production.

GEOGRAPHIC DISTRIBUTION

The area covered by the producing oil fields is small when compared with the size of the earth as a whole. More than half of the world's supply of petroleum is concentrated in two areas, one around the Gulf of Mexico—Caribbean Sea region, and the other around the Caucasian axis. Each represents about 2 per cent of the world's area, and each has produced about 30 per cent of the world's petroleum.

The oil supply of the world is about equally divided between the eastern and western hemispheres. The northern hemisphere, however, produces today about five times as much oil as does the Southern hemisphere. This is accounted for in part by the fact that the land area of the Northern hemisphere is approximately five times that of the Southern, and in part by the different character of the rocks in the two hemispheres.

At the present time all the five continents are producers of oil. They rank as follows: (1) North America, (2) Europe, (3) Asia, (4) South America, (5) Africa. The East and West Indian Islands are also producers.

The producing areas of the United States as ranked in order of importance in 1920 are: [1](1) Mid-Continent (Oklahoma, Kansas, Missouri, northern and central Texas, and northern Louisiana); (2) California; (3) Appalachian; (4) Gulf; (5) Rocky Mountain (Wyoming, Montana, North Dakota, Colorado, Utah, New Mexico, Idaho, and Oregon); (6) Illinois; (7) Lima-Indiana.

FUTURE SUPPLY

In the past fifty years the United States has produced approximately 62 per cent of the world's petroleum. Between 1913 and 1921 the demands of the United States for petroleum and its pro-

---

[1]Day, David T., "Handbook of the Petroleum Industry," Vol. 1, p. 327, 1922. At end of 1922 rank of Appalachian and Gulf areas reversed. Arkansas now included in Mid-Continent.

ducts have increased about 75 per cent. It is highly probable that the peak of the petroleum production has been reached, and the trend today is towards more refined distillation methods and less wasteful production methods.

The world's potential supply of crude petroleum is perhaps most generally placed as being sufficient to last sixteen to eighteen years. That does not mean, however, that there will be no production beyond eighteen years, but it represents the time which it is figured would be sufficient to exhaust the actual and potential supplies were they developed and used at the present rate.

The world's future supply of petroleum will probably come in large part from distillation of oil shales, such as the Green River (Eocene) shales of Utah, Wyoming, and Colorado, and from the distillation of torbanite or cannel coal.

PHYSICAL PROPERTIES

The physical properties most commonly used in describing petroleum are specific gravity, base, color, odor, viscosity, expansion, flash point, and calorific value.

Specific Gravity.—The specific gravity of an oil is one of the most commonly used means of designating its character. Oils range in specific gravity from 0.733 or below to 1.000 or slightly above, as compared to an equal volume of distilled water, taken as 1.000. This decimal system is very extensively used throughout Europe, but in the United States the Baumé scale is employed almost without exception. The Baumé scale is a purely arbitrary one, in which the weight of water is placed at 10°, the degrees increasing as the weight of the liquid decreases, so that the higher the value Baumé the lighter the oil. To convert degrees Baumé to the decimal standard the U. S. Bureau of Sandards gives the following formula, in which the density is taken at 60 degrees F.:

$$°\text{Baumé} = \frac{140}{\text{Specific gravity of liquid}} - 130$$

Specific gravity	Baumé
1.0000	10
0.8750	30
0.7368	60

In general the lighter crude oils, or those of higher Baumé value, yield larger proportions of gasoline and kerosene and are thus of more value. Exceptions to this are natural lubricating oils, which are scarce and command a high price, and some of the heavier oils low in gasoline but high in sulphur-free lubricating stock.

Base.—The "base" of an oil refers to the residue left after the lighter constituents have been removed. Petroleums fall into two general classes, those of paraffin base and those of asphalt base. There is, in addition, what essentially constitutes a third class, which is intermediate between the above given classes and contains both paraffin and asphalt.

In general the paraffin base oils are lighter and yield gasoline, kerosene and light lubricants. The asphalt base oils are usually the heavier oils and are commonly low in gasoline but high in lubricants and fuel oil.

Color.—Petroleum has a wide range in colors, varying from pale-straw and light-lemon yellow colors through greens, reds, and browns to nearly black. By transmitted light most crude oils are transculent, although some are opaque in very thin bodies. By reflected light the crude oils usually have a dark greenish cast, whereas the refined products very commonly have a bluish, irridescent color.

Odor.—Crude oils vary in odor, but in general the odors of the oils from various fields are fairly constant. In general the Pennsylvania oils have a gasoline odor, the oils of Texas and California more commonly have the odor of coal tar, while some of the Lima-Indiana and Louisiana oils have a strong sulphurous smell.

Viscosity.—The viscosity of an oil is of major importance as related to recovery, pumping, and piping. Oils range from those of high viscosity, which approach the consistency of molasses, down to the very fluid oils of low viscosity which flow nearly as readily as water. In general the asphalt base oils are the more viscous. Some of the less viscous paraffin base oils may, however, offer greater piping and pumping difficulties than some of the more viscous oils, because a release of pressure may precipitate paraffin wax, thereby clogging pipes and pumps.

Expansion.—Oils have a tendency to expand with a rise of temperature. The amount of this expansion is of importance in gaging for pipe lines and storage tanks. Expansion is determined by the use of graduated hydrometers, having corrections for temperature.

Flash point.—The flash point of an oil is a measure of its tendency to volatilize into combustible gases. This tendency increases with rise in temperature, and the temperature at which the vapor will ignite under arbitrarily standardized conditions is called the flash point of that particular oil.

Flash point is of vital importance in governing the safety with which oils may be handled and transported, and also in determining whether it falls into the illuminating-oil class or into the naptha class, to be burned as a vapor in internal combustion engines.

Calorific value.—The calorific or heat value of oils varies with the different oils. It is of primary importance in determining the fuel value of an oil. Calorific value is usually expressed in British Thermal Units, one B.T.U. being the amount of heat required to raise one pound of water one degree in temperature, Fahrenheit. The following figures, in B.T.U.'s per pound of material, give a comparison of values: Wood 5,040; peat 7,500; coke 11,500; coal 10,500; fuel oil 18,000 to 22,000. When these value figures are considered alone they give good evidence of the desirability of oil for fuel, but when it is remembered that the storage of oil requires far less space per given amount of available energy, together with its ease of handling

and transportation, it can be very readily seen why the demand for fuel oil is so great.

CHEMICAL COMPOSITION

Petroleum and natural gas are not simple compounds but are mixtures of compounds of carbon and hydrogen. There are also usually present various impurities, such as sulphur, nitrogen, etc., in variable but usually small amounts. The following series of hydrocarbons that have been found in petroleum is taken from Mabery[1].

(1) C_nH_{2n+2}

(2) C_nH_{2n}

(3) C_nH_{2n-2}

(4) C_nH_{2n-4}

(5) C_nH_{2n-6}

Of the above, number (1), the paraffin series, number (2), the olefine series, and number (5), the aromatic or benzine series, are the most common.

DISTILLATION FRACTIONS

The exact chemical analysis of an oil is not as desirable to know as are the fractions or proportions of products that may be obtained on distillation. These fractions are the measure of the value of an oil. The fraction which is distilled off between the initial boiling point and 150°C. constitutes the gasoline fraction; that which comes off between 150°C. and 300°C. constitutes the kerosene fraction. Above 300°C. the various lubricating oils come off in progressive order. The residues left are either further treated by cracking or are used as fuel oils, paraffin, asphalt, or binder material for briquetting powdered fuel.

CLASSIFICATION OF OILS

Crude oils are broadly classified according to the residual material left after boiling off the lighter constituents, usually embracing gasoline, kerosene, and a part of the lubricating fractions. The residue

---

[1]Mabery, C. F., Trans. A. I. M. & M. E., Vol. LXV, p. 505, 1921.

is normally heavy and viscous. This classification gives three types, namely: (1) Paraffin base oils or those with a paraffin residue, (2) asphalt base oils or those with a residue of asphaltic nature, and (3) mixed base oils which give residues containing paraffin and asphalt.

The paraffin base oils are characteristic of the Appalachian fields. They are light in color, generally varying from pale-straw through the yellows and browns. They are relatively fluid, and their content of gasoline and other volatile constituents is high. Their odor is usually that of a refined product and not unpleasant. Chemically these oils are high in hydrocarbons of the paraffin series and low in sulphur and oxygen compounds. They are high Baumé gravity, that is of low density, and consistent with the qualities enumerated bring a high price, due to their content of gasoline, kerosene, and high grade lubricant stock and being low in the harmful sulphur and oxygen compounds.

The asphalt base oils prevail generally in the Mexican, Texas Gulf Coast, and some California fields. Their properties are in general the reverse of those of the paraffin base oils. They are of high viscosity, low Baumé gravity, very dark or black in color, and have a disagreeable odor. The percentage of gasoline is low. Chemically the asphaltic oils are high in sulphur and oxygen compounds and low in members of the paraffin series of hydrocarbons. These oils are generally of low market value and often have a very high percentage of constituents suited best for fuel.

Mixed base oils, which are common in North Texas, Oklahoma, and some Rocky Mountain areas, quite naturally possess properties intermediate in position between the other two types.

The classification given above is commercially useful, as it is generally directly related to the market value of the oil. From a scientific viewpoint, however, it is not exact, for the expressed relations of the physical and chemical properties are not always strictly true.

Petroleum is sometimes broadly referred to high-sulphur and low-sulphur classes. This, with some exceptions, is simply another expression of the asphalt-base and paraffin-base types, respectively, and is correspondingly an index especially to the value of the lubricant stock content, the quality of which is largely dependent upon the amount of harmful sulphur compounds present.

It would be very difficult to arrange a concise classification of the petroleums, for their properties would overlap from one proposed class to another, rendering such a classification of little value.

RELATIONS BETWEEN PETROLEUM, COAL, AND NATURAL GAS

General relations.—The frequent occurrence of petroleum, coal, and natural gas in the same geological formation and the relations of each of these substances to the others has been a popular field of investigation among petroleum geologists.

A great deal is known about petroleum. Its chemical nature has been partly worked out, its physical properties have been more or less fully determined, and its mode of formation and alteration at least partly established. However, its highly complex chemical nature and the readiness with which its constituents decompose during analysis, together with the fact that it is often separated from its source, have all been instrumental in presenting many problems which have not been solved. There is, therefore, much that is unknown concerning petroleum.

The nature and origin of coal and the changes which it undergoes subsequent to its formation are fairly well understood.

The general nature and properties of natural gas have been determined, and the process of its formation under specified conditions can often be traced step by step, but there are numerous conditions which might result in the formation of similar gases, and, too, the mobile nature of gas may permit migration away from its source. Consequently it is often difficult to determine the genetic history of any particular deposit of natural gas. It is a definitely established

fact, however, that most deposits of natural gas have been derived from either petrolum or coal.

The paraffin series.—Although chemically petroleums are known to contain members of at least five series of the carbon-hydrogen compounds, certain general relations are clearly brought out by a consideration of one of these series of hydrocarbons, namely, the paraffin or methane series, which is a principal constituent of the oils of the Appalachian fields.

The paraffin series has the general chemical formula CnH^2n+^2 That is, in each member of the series the number of hydrogen atoms is twice as great as the number of carbon atoms, plus two.

Following is a tabulated list of some of the more common members of the paraffin series, showing the name, chemical formula, boiling point, Baumé gravity, and consistency of each, also the commercial products into which the members fall. The table is necessarily generalized and is intended to show general relations only, for the complex nature of the hydrocarbons and variation in refinery practice precludes precision.

Some common members of the paraffin series

Consistency	Name	B. P. C.	Be.	Chemical formula	Products
Normally gases	Methane Ethane Propane Butane	—164° —84.1° —37° +1°		$C\ H_4$ $C_2\ H_6$ $C_3\ H_8$ $C_4\ H_{10}$	Natural gas
Normally liquids	Pentane Hexane Heptane Octane Nonane Decane	37° 69° 98° 125° 150° 173°	93° 83° 75° 69° 65° 62°	$C_5\ H_{12}$ $C_6\ H_{14}$ $C_7\ H_{16}$ $C_8\ H_{18}$ $C_9\ H_{20}$ $C_{10}\ H_{22}$	Gasoline and Kerosene
Normally thick liquids and solids	Lower members				Lubricants, Paraffin and thick residues.

(Note: B. P. C.=Boiling point Centigrade; Be.=Baumé gravity).

An examination of the above table reveals a number of important relations which are true of petroleum in general. The series is arranged in order of increasing number of carbon and hydrogen atoms as we pass to the lower members, the ratio CnHn +2, however, being maintained.

The first four members are normally gases. This is clearly shown by their low temperature boiling points. Ordinary natural gas embraces this group. Below the gases are numerous members which are normally liquids, including the gasoline, kerosene, and some of the lubricant fractions. Passing still lower in the series we find substances which are solids under ordinary conditions. These are the chief constituents of paraffin wax. Thus as we pass from higher to lower members we find in progressive order a gradational change in consistency from the gaseous state to that of a liquid and finally to a solid. Similarly, the boiling points show a steady decrease in tendency to volatize, with a corresponding decrease in Baumé gravity.

The refining of oil utilizes the difference in boiling points as a means of separating the commercial products. Also it has been found that the application of high temperatures under proper conditions will cause the lower members to decompose chemically, splitting up into new members with fewer atoms higher up in the series.This process is called cracking and increases the high value gasoline recovery from an oil by changing into gasoline the lower members which would normally bring a lower price.

Simultaneously with this increase in the higher members, new members are formed which fall very low in the series and contain some free carbon as well as concentrated impurities. In refining these are embraced in the heavy residue. Thus the cracking process generates light, volatile products, and also heavy residues with free carbon, from the same material.

In Nature the cracking process is constantly going on. Here the heat is usually less intense than in artificial refining, but the time

is greatly increased, and such additional factors as very high pressure, movement, shale filtration, etc., come into action, and the result is similar to that in artificial refining. Petroleum in the earth, therefore, is constantly changing. An ideal type expression of this change would be the alteration of an average-grade petroleum into high-grade, light petroleum and asphalt. The former would in turn go over to still lighter products and finally to natural gas, while the latter would correspondingly be lowered in grade with an increase in fixed carbon, eventually forming graphite.

The factors, pressure, heat, movement, etc., which bring about the alteration of petroleum, are associated with and roughly proportionate to earth folding and general deformation of the strata. The intensity of deformation, with due consideration to the time element and pressures due to overlying rocks, is therefore an index to the stage of alteration reached by any petroleum present. Obviously if the oil has reached the gas and asphalt or graphite stage it is no longer recoverable as liquid oil.

During all stages of alteration except the very last, when graphite is being formed petroleum is low in free carbon and soluble in such solvents as carbon disulphide, ether, and chloroform. There is also a tendency of the thick or solid phases of petroleum to melt on the application of heat. Petroleum is normally regarded as being derived from animal and vegetable material deposited in salt water.

Coals.—Coal is formed from vegetation covered by water which shuts out the air, thereby preventing decay. The conditions necessary to the formation of coal are commonly fulfilled in many swamps of the present time, where plant matter falls into the water, gradually sinks into the mud and is sealed up away from oxodizing conditions which cause decay.

The main constituent of vegetable matter is cellulose, a compound of carbon, hydrogen and oxygen.

Just as petroleum is altered by such factors as pressure, heat, movement, time, etc., the buried plant remains undergo a natural distil-

lation liberating methane gas, water vapor and other gases, at the same time forming free carbon. During the earlier stages of the change bacterial action is probably important. In the course of time the material successively passes through the stages of peat, lignite, and bituminous coal, and, if the alteration factors are sufficient in magnitude, the anthracite coal stage and finally the graphite stage are reached. Each of these substances is derived from the preceding one with the liberation of volatile matter and an increase in fixed carbon. The latter is absent in the original vegetable matter and constitutes nearly 100 per cent of graphite, while volatile matter in the vegetation is high and almost absent in graphite.

Coals are relatively insoluble and usually do not melt on heating. Most of them are low in condensable hydrocarbon gases. They are normally a product of the land and usually of fresh or brackish water burial.

Natural gases.—By far the most important of the natural gases are the hydrocarbon gases already discussed in connection with petroleum and coal, from which they are derived. In addition the following gases are found more or less associated with those mentioned: Air, nitrogen, carbon dioxide, carbon monoxide, hydrogen sulphide, argon, xenon, neon, crypton, and helium.

The hydrocarbon gases are all inflammable. They are often divided into two groups, namely, the dry or non-condensable group and the wet or condensable group. Dry gas consists largely of methane, which as indicated in the paraffin series table, is the highest and most volatile member of the oil series. It is so highly volatile, with a boiling point of—164° Centigrade, that it will remain in a gaseous condition, resisting ordinary liquification methods, such as application of low temperatures and reasonable pressures. It is consequently called a dry gas. Wet gases, as the name indicates, may be readily condensed into the liquid state. This group is high in ethane, propane, and butane. These gases have higher boiling points than methane and are more readily condensed. Along with these three members,

which, as indicated, are normally in the gaseous state, there is usually more or less volatilized pentane and hexane.

Wet gases on condensation yield an important commercial product, casing-head gasoline, which is naturally highly volatile and dangerous to handle. It is usually mixed with kerosene to give an intermediate product known as blended gasoline. Wet gases are considered to have been recently in contact with liquid petroleum. Dry gas does not necessarily have significance with reference to oil, for it may have come from other sources.

The gases mentioned as being associated with those of a hydrocarbon nature have no known direct connection with oil. They are non-condensable and are sometimes referred to the dry gases along with the non-condensable hydrocarbon gases. With the exception of carbon mon-oxide and hydrogen sulphide these associated gases are not inflammable. Air in natural gas is thought to represent atmosphere entrapped in the rocks. Nitrogen is often the residue from air after removal of the oxygen. Carbon dioxide and carbon monoxide are common oxidation products of vegetable matter. Hydrogen sulphide is often generated by the decomposition of pyrite, which is a very common mineral. Argon, xenon, neon, krpton, and helium usually occur only in small quantities. All of these except helium probably are derived mostly from the atmosphere. Helium is thought to come from the spontaneous alteration of radium. It is very light and is incombustible. Due to these properties it may be used to inflate dirigible balloons.

Summary.—Following is a tabular summary showing some general relations between the petroleum or paraffin series and the coal series, each of which contributes to the world's supply of natural gases.

Comparison of Petroleum Series and Coal Series

Petroleum series		Coal series
Gas		Vegetation
Light petroleum		Peat
Heavy petroleum		Lignite
Asphalt	Cannel Coal	Bituminous coal
Graphite		Anthracite coal
		Graphite
Mainly liquid or semi-liquid, low in fixed carbon, relatively soluble in carbon disulphide, chloroform and ether, melt on heating, high in condensable hydrocarbons. Series principally of salt water origin, from animal and vegetable matter.		Mainly solids, high in fixed carbon relatively insoluble in carbon disulphide, chloroform, and ether, do not melt on heating, low in condensable hydrocarbons. Series principally of fresh-water origin, from vegetable matter.

In examination of the table it is of interest to note that asphalt of the petroleum series merges into certain bituminous coal known as cannel coal. At this point the chemical and physical properties of each series are about the same. This relation suggests that petroleum might be formed from coal, but the theory is not well substantiated. Although petroleum and coal are often found in the same area, one overlying the other, they normally occur in different beds deposited under different conditions of sedimentation. The stratigraphic relation is generally such that obviously the petroleum and coal have come from a different source.

The commonly accepted general relations between petroleum, coal, and natural gas have been outlined, but there is not sufficient knowledge on the subject to define the boundaries with precision. It is not known to what extent the same material might be capable of forming either series, or to what degree it is possible for members of one series to be converted into material falling into the other. It is also noted that graphite is a common resultant product of both petroleum and coal. It seems that the exact laws governing the relations between petroleum and coal have not been ascertained.

In testing new areas for oil it is of vital importance to know whether the alteration of any possible petroleum present has progressed beyond the liquid-oil stage. Very often coal beds of greater or less magnitude are present at or near the surface and available for

A. BARNWELL SANDSTONE, CLARKE'S MILL, JEFFERSON COUNTY, 7½ MILES NORTHWEST OF LOUISVILLE.

B. OCALA LIMESTONE EXPOSURE ON FLINT RIVER, CRISP COUNTY.

study. As stated elsewhere in this report, David White has approximately defined the limit beyond which petroleum is more or less completely converted into other products, in terms of the per cent of fixed carbon in the coal of the area, on a pure coal basis. He has found that where the fixed carbon ratio is greater than about 65 per cent most of the petroleum will have passed beyond the liquid state. Coal of this 65 per cent stage falls in the bituminous class.

CONDITIONS ESSENTIAL TO THE FORMATION OF PETROLEUM IN COMMERCIAL QUANTITIES

Commercial production of petroleum is dependent on a number of factors. These have been grouped by the writers under the four major headings of (1) source, (2) conversion, (3) accumulation, and (4) retention.

There must first be material from which oil may be derived, and this material needs then to be converted into liquid oil. After the formation of the liquid petroleum it is necessary that it be collected in commercial quantities, and it must be retained both during conversion and during succeeding time. All four of the above major conditions must be fulfilled and not one can be omitted.

The question of origin of petroleum is here not treated separately, but is briefly discussed under the headings of "Source" and "Accumulation."

SOURCE

There are two main theories advanced for the origin of petroleum and natural gas. These may be styled the inorganic and the organic theories.

Inorganic theory.—The inorganic theory of the origin of petroleum and natural gas has been advanced and supported mainly by chemists. This theory is based primarily on the assumption that the waters and gases within the earth, reacting with other chemical compounds, generate the hydrocarbons, which are later collected in favorable reservoirs.

"Berthelot showed that carbon dioxide at high temperatures can react on free alkaline metals, which some have supposed the interior of the earth contains, and can yield acetylene, which would break down, forming higher hydrocarbons. He showed that acetylene heated to high temperature yields benzene."[1]

Other chemical theories along somewhat different lines have been advanced to account for the origin of petroleum from inorganic sources, but the basic principles are along the lines given above and need not here be discussed.

Today the inorganic theory of the origin of petroleum is not regarded as of very great importance by most petroleum geologists, in spite of the fact that hydrocarbons have been produced experimentally from inorganic sources. Some of the strongest arguments against the acceptance of the inorganic theory are: (1) The almost universal barrenness of igneous and crystalline rocks except in cases where they were very clearly not the original source of the oil but acted merely as reservoirs; (2) petroleum reservoirs are generally tightly sealed and would be difficult of access to petroleums coming from depth; and (3) practically all commercial production to date has come from sedimentary rocks.

The inorganic theory of origin, however, appears to be both possible and plausible, but as a practical explanation it is not supported by the great mass of field evidence.

Organic theory.—The first expression of the theory that petroleum is derived by natural distillation from organic matter contained in sedimentary rocks was suggested by J. S. Newberry in his paper on the "Rock Oils of Ohio," published in the Ohio Agricultural Report for 1859. The theory was again set forth and emphasized by Newberry in Vol. I, of the Ohio Geological Survey, in 1873, and by Edward Orton in Vol. VI of the Ohio Geological Survey, 1888.

It is now commonly accepted that petroleum and natural gas are derived from organic matter. Both plant and animal matter have

---

[1] Emmons, W. H., "Geology of Petroleum," p. 80, 1921.

been assigned as the sole source of petroleum and natural gas, but from the evidence in hand it appears that some oil is derived from plant remains, some from animal remains, and some from a combination of the two. Plants are now probably regarded as the more important source.

The organic remains that furnish the material for petroleum and natural gas are laid down in the sedimentary rocks at the time these rocks are deposited. Most commonly the rocks which contain oil-forming matter are laid down in the salt waters of the seas and oceans, though some fresh-water materials contain large amounts of matter which may be converted into petroleum by artificial means.

All areas where there are considerable thickness of sedimentary rocks that have not been too highly metamorphosed offer possibilities for commercial quantities of petroleum, on a purely lithologic basis, but shales, limestones, marls, and dolomites are the principal petroliferous or oil-yielding rocks. Of these source rocks shales are by far the most important. This is to be accounted for because shales make up from 65 to 80 per cent of all sedimentary rocks, and because in the areas in which shales are deposited the conditions are most favorable for the preservation of the oil-forming matter. The muds which form the shales are usually laid down in shallow, quiet water near shore lines.

No definite limit can be placed as to the minimum thickness of source rocks that will furnish oil in commercial quantities, but it is safe to say that where petroliferous rocks are thin and poorly represented the petroleum possibilities are not normally good. In many of the oil fields the petroliferous shales that have furnished the oil-forming matter attain thousands of feet in thickness. Moreover, the amount of oil-forming material in the rocks varies greatly, and where the material is very abundant great thicknesses of rock are not always necessary.

Throughout a large part of geological time there has probably been abundant life to furnish large amounts of oil-forming matter, and its

absence in many of the sedimentary rocks is due to a lack of its preservation rather than to its absence from the seas and oceans.

CONVERSION

Geologists are not all in accord as to the process of conversion of organic matter into petroleum or as to the time at which this conversion takes place. The three most prominent ideas advanced are: (1) That the petroleum results from the natural distillation of oil-forming matter in the rocks, that is, the material has not been broken up into different products at the time of deposition, but that the liberation of the waxes and fats and their conversion to petroleum all takes place long after deposition, and is attributable to pressure, and probably heat, caused by compacting and movement, with the time element always present. (2) That at the time of deposition of the organic matter bacterial action liberates the waxes and fats, which would normally tend to rise to the surface as tiny globules. But in even slightly turbid waters these globules would attach themselves to clay particles, which would sink, and the fatty matter would then become entombed in the rocks, to be later converted into liquid petroleum, by pressure and heat caused by compacting and movement. (3) That the bacterial action on the organic matter causes the direct conversion to liquid petroleum, which is thus contemporaneous with the strata in which it was originally contained.

The present trend of thought among some petroleum geologists is that the conversion of animal matter to petroleum takes place soon after deposition, whereas the conversion of the plant matter probably takes place long after burial.

It is not within the scope of this bulletin to enter into any exhaustive discussion of these general ideas and their many modifications. It will suffice to say that all three carry weight and probably not one alone embraces all the facts.

Today it is difficult to say which idea is the most generally accepted. If it is assumed that oil is preponderantly of vegetable origin

it is probable that the first theory, that of natural distillation, is the most important. In cases where the source of the oil is animal matter the third theory, that of direct conversion to liquid petroleum at time of deposition, would probably be the more applicable. The presence of gas, which must, in large part, have been formed after the reservoirs were sealed, the presence of oil in structures sealed long after burial, and the relation between the degree of fixed carbon in the rocks and the grade of the oil, all constitute strong evidence that in many cases the second theory (that of the liberation of the waxes and fats at time of deposition and their subsequent conversion, due to pressure) must be of major importance, unless we assume that the oil was formed at the time of deposition and was later subjected to metamorphism, giving rise to gas and to a changed character of the oil. Such an assumption is in many cases unwarranted by the conditions which prevail.

Whether or not movement is the agent of primary importance in the conversion of the oil-forming matter into petroleum, it is certain that the amount of deformation of the strata has a very direct bearing on the character of the oil, and the deformation of the strata may even be so great that the previously liquid oil becomes mainly fixed carbon and may never thereafter be recovered as liquid petroleum. The two following laws as given by David White furnish the best statements of these metamorphic effects:[1]

[1]*"In regions where the progressive devolatilization of the organic deposits in any formation has passed a certain point, marked in most provinces by 65 to 70 per cent of fixed carbon (pure coal basis) in the associated or overlying coals, commercial oil pools are not present in that formation nor in any formation normally underlying it, though commercial gas pools may occur".

---

[1]Johnson and Huntley, Oil and Gas Production, p. 23, 1915.

[2] "The lowest rank oils of each type are found in the regions and formations in which the carbonaceous deposits are least altered .... the highest rank oils being, on the whole, found in regions where carbonaceous deposits .... have been brought to correspondingly higher ranks".

Whether or not the development of structures, such as domes, anti-clines, etc., are of major importance as regards the formation of oil will perhaps long remain a matter of speculation. But certainly they do play a very important part in the accumulation and will be dealt with under that heading.

ACCUMULATION

GENERAL PRINCIPLES

When liquid oil is formed it is more or less scattered throughout the rocks. Therefore in order to get quantity production at any point it is necessary that the oil be concentrated. This necessitates migration to a common centre, which takes place when several requirements are fulfilled. First, porous beds must be present, containing open spaces, such as those between the individual grains in a sandstone, in order to provide a passageway along which the oil may move during accumulation, and also to serve as a reservoir at the point of concentration. Secondly, the porous bed must be overlaid, and usually underlain, by relatively non-porous material, thereby confining the oil to restricted zones and preventing its being scattered. Thirdly, there must be some force acting on the oil along converging directions, thereby concentrating it at a common centre from over a relatively large area. It is furthermore necessary to have selective action toward oil, as compared with water, in order to separate the two. Oil is rarely found without associated water, which usually carries considerable salt in solution.

POROSITY OF ROCKS

Sandstones are normally the most porous type of sedimentary rock. Usually their pore space varies from about 10 per cent to about 30 per cent of their volume. Limestones as a rule are much more

compact than sandstones, but sometimes have a relatively high porosity, generally due either to a loosely compacted nature, as in fossil coral reefs, or to extensive water channeling from solution, or to fracture fissures, or to the concentration accompanying certain changes in mineral nature. Shales and clays contain an abundance of minute openings, but these are so very small as to prevent free movement of any oil or water contained in them.

Since, as previously stated, most oil originates in shales, and since these usually contain sand members with the necessary porosity, it naturally follows that in the majority of fields the oil is found concentrated in these sand beds. In many instances, however, oil is concentrated in porous limestones, the limestone itself, or some other bed, perhaps of shale, being the source of the oil. Accumulations of oil in shale are not unknown, but they are not of commercial importance. Effective porosity is probably always a requisite to quantity production.

IMPERVIOUS CAPPING

Shales, clays, and dense limestones are the most non-porous types of sedimentary rocks. All of these are common as impervious capping necessary to confine the oil during and after accumulation. Very fine-grained, compact sandstone, especially when saturated with water or oil, is relatively impervious unless subjected to high unbalanced pressures. A bed may be the source of oil which migrates into an adjacent porous sand, and then function as a relatively impervious capping confining the oil to the porous bed.

FORCES CAUSING THE MOVEMENT OF OIL

The following forces are probably the most important in causing the movement of oil: (1) The buoyancy of oil when associated with water, with which it will not mix, causing the oil to rise on top of the water; (2) the force of moving water or gas tending to carry the oil along with it; (3) static gas and water pressure; (4) capillary attraction; and (5) compacting of beds squeezing out the oil into other more porous beds. Sudden earth movements, such as those accompa-

nying faulting, are considered important in starting the movement of oil.

FAVORABLE STRUCTURES

In order to bring about the concentration of oil it is necessary that the attitude of the strata be such as to bring one or more of the above mentioned forces into action, causing the oil to move. It is also necessary that the induced movement be toward a common centre. Any attitude of the beds which will fulfill these two requirements is termed favorable structure, with reference to the accumulation of oil and gas. In harmony with these principles it may be conservatively stated that nearly all the producing wells of the world are located on favorable structures, beneath which the oil is trapped in pools, occupying the inter-granular spaces of porous beds.

Three types of favorable structures are common: (1) folded strata, (2) closed monoclinal strata, and (3) lens-shaped porous beds.

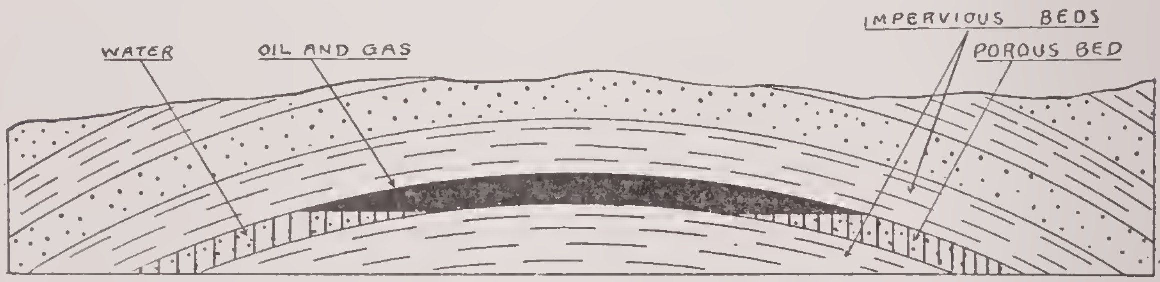


Fig. 1.—Simple anticline with oil and gas (solid black) collected in porous bed at crest of fold.

Folded strata.—Figure 1, illustrating a simple fold, shows the most common form of this type of structure. Force No. 4, (capillary attraction) assisted by force No. 5 (the compacting of beds) are instrumental in moving the oil from its source in the shale to the porous sand, where the water, oil, and gas all occupy the open spaces between the individual grains. The oil being lighter than the water, and so constituted as not to mix with water, rises on top of the latter to the upper part of the fold, and from each side, as indicated. In a similar way the gas rises on top of the oil to the extreme crest of the

fold, the water occupying a position well down the sides. Thus force No. 1, exerted through buoyancy, is brought into play, moving the oil to a common centre, the crest of the fold, from each side. Also the gas, rising in response to great bouyancy, carries the oil up with it, utilizing force No. 2. It is also generally true that strata are more intensely compacted, from folding, down the slopes than around the crest of a fold, thus squeezing the oil away from the lower parts toward the more porous crest, thereby engaging force No. 5. Force No. 3 (the static pressure of water and gas) tends to hold the water and gas entrapped in the fold as indicated. It is thus seen how the simple fold illustrated brings into play five forces which collect the oil from a relatively large area on the sides of the fold, carrying it up to a common point, and causing accumulation around the crest in the manner shown by figure 1.

There are many modifications of the simple fold shown, all of which in general are effective in causing accumulation through the principles outlined. If the folding is so intense as to break the strata it is possible that a large part of the oil and gas may escape.

Simple folds which are relatively long and narrow are called anticlines, while the term dome is applied to those having a width relatively great as compared to length. The anticline is probably the most common general form of structure favorable to oil and gas accumulation.

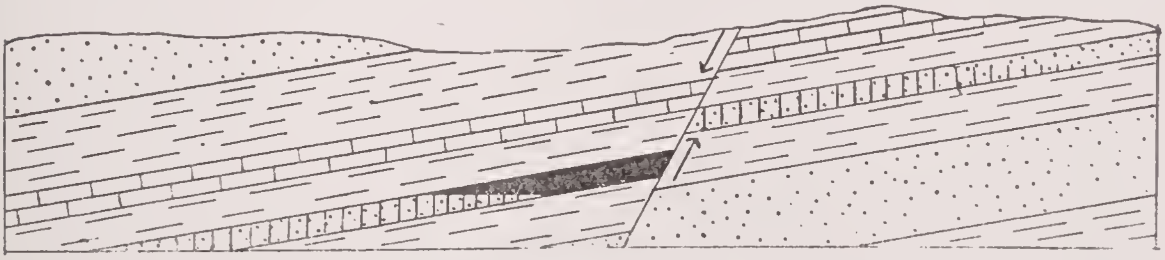


Fig. 2.—Faulted monocline. Oil and gas (solid black) collected on downthrown side of fault.

Closed monoclinal strata.—Monoclinal strata or beds dipping in one direction only probably rank next in importance to folds in the accumulation of oil and gas. The faulted monocline shown in figure 2,

falls in this class. In this case the concentrative forces are in general similar to those operating in folded strata shown in Figure 1. Here the gas and oil would continue to move up dip, through the porous sand bed, and escape at the surface as an oil and gas seepage were there no interruption in the passageway. This is prevented, however, by a break or fault in the beds, with relative movement in the direction shown by the arrows. The compact shale on the right of the fault line is thrown opposite the porous oil sand on the left, thereby sealing the latter by blocking the open passageway at this point. The movement along the fault plane tends to form pulverized material called gouge, which often seals the porous bed to the left of the fault, irrespective of what bed may be brought opposite it. Effective sealing may result from the deposition of residual hydrocarbons, like asphalt, or of mineral matter, such as calcite, from solution. The water, oil, and gas will be arranged as indicated, with accumulation a short distance down dip from the fault. In case the break is not sealed by impervious matter the oil and gas may escape, just as they would under similar conditions in folded strata.

Figure 3 shows another common closed monoclinal structure favorable to accumulation. Here the principles involved are similar to those of Figure 2, except that the up-dip movement of oil and gas, instead of being blocked by a sealed fault, is stopped by the porous sand changing to impervious shale or clay, thus terminating the open passageway.

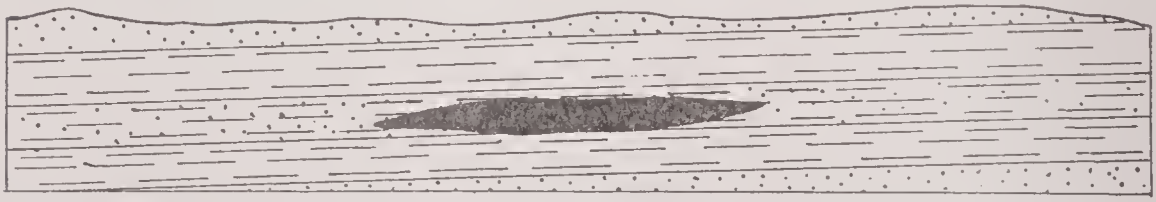


Fig. 3.—Porous lens on monocline. Oil and gas shown in solid black.

In figures 2 and 3 the up-dip movement of the oil is stopped by the termination of a free passageway. Another attitude of the beds,

the terraced monocline shown in figure 4, often results in accumulation of oil at the point indicated. Here the oil moves up-dip, due to forces already discussed, dependent upon the steepness of dip. On meeting the flattened attitude of the bed the forces are correspondingly lessened, preventing further movement and resulting in concentration where the steepness of dip changes. If the water present has even slight movement, down-dip concentration from above the flattened area may take place. A structure of this nature is called a terrace.

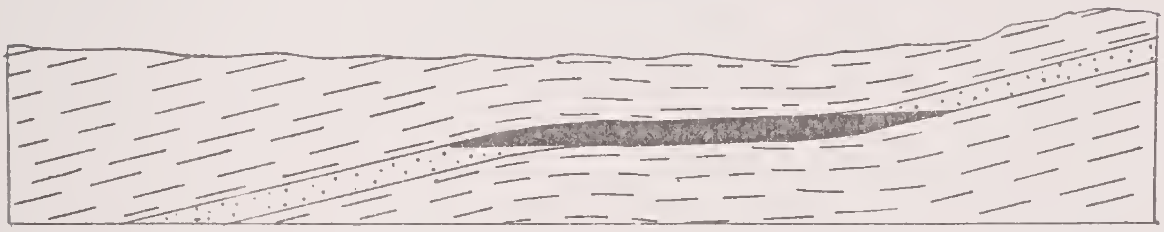


Fig. 4.—Terrace on monocline. Oil and gas (solid black) collected in porous bed on the terrace.

Lens-shaped porous beds.—Structures of this nature in horizontal strata are of much less importance than where the strata are folded or inclined. Figure 5 illustrates this class of structure. Here capillary attraction and the compacting of the shale carry the oil from its source in the shale into the sand lens. Gas and more or less water will usually be present and the oil and gas will be concentrated as shown. This type of structure usually does not gather the oil from over a very large area, but simply draws it from the beds immediately adjacent to the sand lens. Some sand lenses probably contain only oil and gas, due to the fact that the water, having a greater capillary attraction than oil, might leave the porous sand and enter the adjacent bed, where the small size of the pores gives gerater capillarity, thereby exerting a greater attraction toward the water than the oil. The fact that water has a greater capillarity than oil seems to be unquestioned, but the ability of the water in the sand to replace the oil already in the fine-grained shale is questioned. The fact that oil is generally

more viscous than water would tend to retain the oil in the coarser grained sand, while the water, due to its relative fluidity, might enter the fine pores of the shale. In any event, when oil and water occupy beds of variable porosity the oil tends to become segregated in the more porous zones. Commercial accumulation of oil and gas in structures of the above type are important in some fields.

Fig. 5.—Lens-shaped porous bed in less porous strata. Oil and gas solid black. Beds horizontal.

Other structures.—The sketches shown in Figures 1 to 5, inclusive, are idealized to more clearly represent the principles involved in accumulation. They illustrate some of the more common types of simple favorable structures without showing the common, more or less complex, modifications or specific structures represented by compound anticlines, plunging anticlines, salt domes, igneous domes, and monoclines sealed by dikes, etc. Compound anticlines are composed of more than one fold, which to a greater or less extent merge into a single structure, and sometimes with superposition of small folds or domes on a larger fold. Plunging anticlines are those having an axis inclined to the horizontal. Salt domes are those underlain by great cores of salt. These are common in the Gulf Coast area of Texas and Louisiana. Igneous domes are those formed by intrusions of molten igneous rock. In monoclines sealed by dikes igneous material has broken through the reservoir beds, sealing them up at the point of contact in a manner similar to that in sealed faulted monoclines. In the common structures just enumerated the principles of accumulation are the same as described under their respective types.

Summary of structures.—From a consideration of the structures described it is evident that in general structures favorable to accumulation of oil and gas imply porous beds, impervious capping, folded or otherwise deformed strata, and water. However, there may be exceptions, illustrated by the porous lenses in strata which are horizontal. Also, when abundant water is absent the oil, with no water to float on, may move down dip from gravity and become concentrated well down the sides of structures. Ideal conditions of this type would give accumulation at the lowest point of the strata, such as the trough or syncline between two anticlines. Productive structures of this nature are found in numerous fields, especially in the Appalachian area, but they are the exception rather than the rule, for water is one of the most important factors in accumulation.

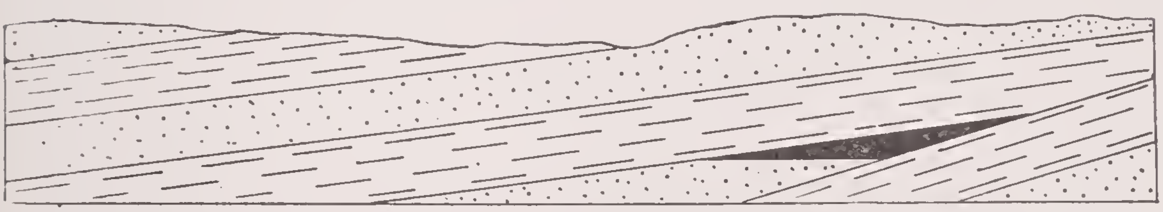


Fig. 6.—Reservoir formed by an unconformity. Oil and gas in solid black.

The importance of favorable structure with reference to commercial production can scarcely be over-estimated. It is undoubtedly next in importance to the presence of oil or oil-forming matter itself. The pressure, movement of beds, etc., incident to folding or any form of deformation is also known to be a factor in the changing of oil-forming matter into liquid oil. Structures, therefore, are not only active in the accumulation of oil and gas but are produced by forces which are regarded as conversion factors also. The relative importance which structure bears to each of these processes cannot be definitely stated.

RETENTION

The fourth and last major requirement to be fulfilled in order to produce commercial quantities of petroleum is retention. The oil-forming material, the waxes and fats, and the liquid petroleum must

be prevented from escaping. This is accomplished by impervious retaining material. Without this retention the petroleum formed during past geologic time would never have been preserved until the present day.

The presence of impervious retaining material, whatever its character, is necessary not only after the oil has been collected in favorable reservoirs, but also at the time of the deposition of the oil-forming matter and during the time intervening between deposition and collection as liquid oil in reservoirs.

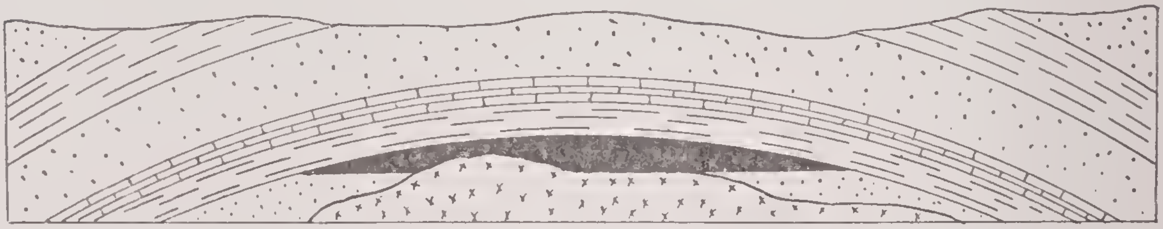


Fig. 7.—Simple anticline formed by doming effect of salt plug. Oil and gas in solid black.

Whether we assume that the whole of the conversion from organic matter into petroleum takes place after burial, or that it takes place either wholly or in part at the time of deposition, it is essential that from the very time the material is deposited it must have over it some covering to exclude the air, thus preventing oxidation and evaporation. The principle of burial and exclusion of oxygen perhaps offers one of the best reasons why the muds and clays, when changed into shales, are the great source rocks of oil. Muds and clays are normally laid down in quiet waters, practically barren of free oxygen. Moreover, the clay particles act as an impervious seal against the escape of the waxes and fats, due to the attraction which they exert on the tiny particles, as previously mentioned.

An impervious covering for a favorable reservoir really has a double function. In the first place, without this impervious covering over porous strata there could hardly be a true reservoir, for the porous strata would not normally offer a suitable place of lodgment for

the oil. Then, after the oil has been collected in reservoirs it is very commonly subjected to both gas and hydrostatic pressures. In order that it may not be forced out of the porous rocks it is necessary that the latter should remain overlaid, and usually underlaid, by relatively impervious rocks.

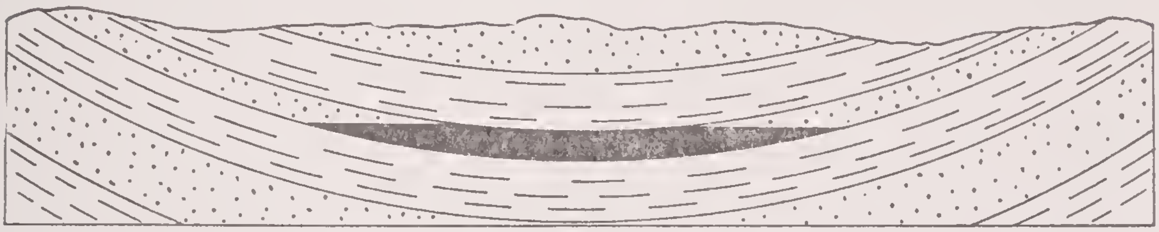


Fig. 8.—Simple syncline with oil and gas (solid black) collected in porous bed in the bottom of fold.

The commonest of these impervious cap rocks are shales and clays, though often very dense limestones and dolomites serve. In the case of the shales and clays, their actual porosity may be high, but the pore spaces are so small that the oil may not enter. Shales and clays are especially impervious to oil when they are saturated with water, the oil lacking the power to force the water out of the fine pores. In the case of dense limestones and dolomites acting as the retaining strata, imperviousness is due mainly to the actually small amount of their pore space.

Modifications of the above general statements are to be found in such cases as where evaporation of some of the oil in a porous bed has so clogged the pores as to form a dam to further escape of the oil. This normally effects a porous bed at its outcrop at the surface and practically implies some impervious covering over the greater part of the stratum.

Faults may cut across strata or igneous dikes may be intruded through them, forming very effectual dams to migration through porous strata, thereby forming a favorable collecting ground. Again, this normally implies, in each case, a relatively impervious covering above the oil-bearing stratum in order to make the damming effective.

There are a number of factors which operate against the retention of oil in pools. The first, the most important, of these, is the breaking of the strata. Other factors of importance are deep valley cutting, change in water level, and igneous activity.

All of the above conditions tending to offset retention, with the last named excepted in some cases, are caused primarily by earth movements subsequent to the collection of the oil in the reservoirs. As has already been pointed out, movements of the earth's crust both fold and fault the rocks. These folds and faults may form the favorable reservoirs, but very often the folding is so intense that the strata are both fractured and faulted, and these openings may very readily serve as means of escape for at least part of any oil that may have been present.

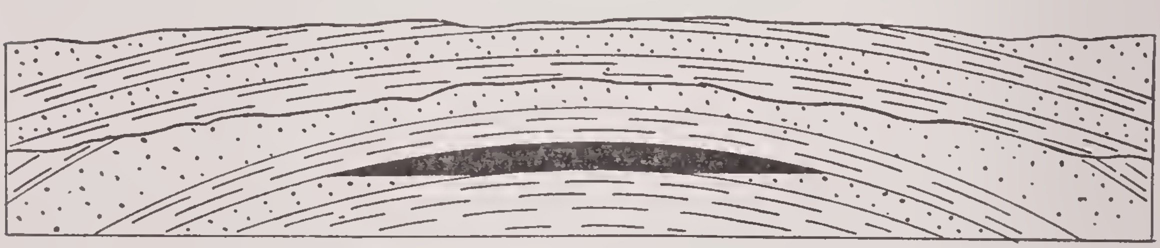


Fig. 9.—Showing increase in folding beneath an unconformity. Oil and gas in solid black.

Earth movements may, and very commonly do, result in uplift of the land areas. This may cause renewed erosion, cutting away the covering of the reservoir rocks. Very often, however, the petroleum reservoirs are buried sufficiently deep to be protected against erosion for almost infinite periods of time.

Directly related to elevation and erosion is change of water level. Very commonly the lower surface of the oil rests on water, and if this water is, for any reason, withdrawn, the oil will tend to follow it and go down the limbs of the structures by gravitational action. (In the case of oil in dry rocks in synclines, the intrusion of water may force the oil up the limbs of the structures.) Deep erosion tends to furnish openings permitting the entombed ground water to escape, thereby lowering its level within the strata. Solu-

tion action may likewise release the underground waters with consequent change of level.

The intrusion of igneous rocks into the sediments may either act alone or accompany earth movements. The accompanying heat may entirely disperse any existing oil in the rocks invaded, the magnitude of the intrusive mass and its proximity to the reservoir being the governing factors, assuming of course that the mass is hot.

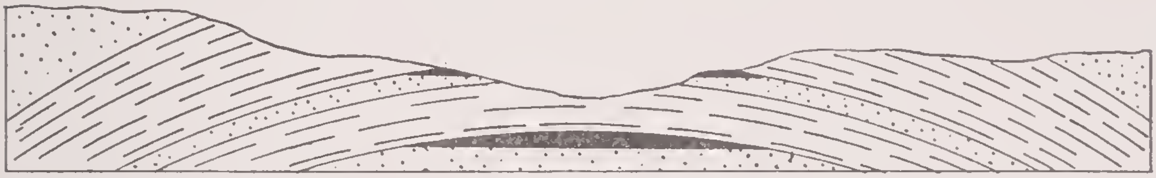


Fig. 10.—Exposure and removal of former reservoir rocks by erosion. Oil and gas in solid black.

It should thus be generally clear that there are certain conditions, such as impervious coverings, that must be looked for in connection with oil collection. It should also be borne in mind that faults, folds, and igneous intrusions may be either desirable or undesirable features, and always their degree and the particular conditions should be noted, and each area considered on its own merits.

LOCATION OF OIL AND GAS TEST WELLS

There have been stated, in the foregoing section, the major conditions which must be fulfilled before commercial production of petroleum or natural gas may be expected. These conditions are by no means always easily recognized and can often only be determined by careful prospecting of a region. Such prospecting is normally stimulated by, and based on, two sets of data which are here termed non-structural and structural. They include both surface and subsurface factors.

Non-structural factors.—The first of the non-structural factors bearing on the occurrence of petroleum to be considered is the rock column and sequence of the region under consideration. In regions

of igneous rocks or highly metamorphosed rocks of any type prospecting for petroleum is little warranted. Any area of sedimentary rocks not too highly metamorphosed offers a possibility for petroleum. Where the rocks are of a petroliferous character, such as some shales, and there are also present reservoir types of rocks, like porous sandstones, and where such rocks are of considerable thickness, prospecting is better warranted. Often the rock sequence and character can only be learned from more or less distant outcrops and from well cuttings.

Another set of non-structural data that commonly stiumlates interest and prospecting is what may be called surface indications of petroleum. These includes the presence of deposits of asphaltum, paraffin, gilsonite, etc., oil seeps; gas seeps; mud volcanoes; burned shale; and salt water.

In many areas deposits of heavy hydrocarbons are to be found. They may occur as deposits of asphalt or gilsonite etc., or they may be in the form of bituminous rocks (rocks impregnated with the hydrocarbons.) Such deposits are the result of the evaporation of the more volatile constituents of petroleum. They usually occur along the outcrops of the oil-bearing formations or around openings, such as springs, fractures, faults, etc.

Seeps of petroleum itself are common in many areas, and often indicate quantity supply at depth, but do not necessarily point to commercial accumulation below the point of issue, as the oil may have come from a long distance away. Sometimes seeps and deposits of the heavier hydrocarbons are far removed from productive regions and are thereby misleading for the immediate area, but offer hopes of production from the same formations, where those may be buried and where structural conditions are favorable.

Gas seeps are common in many regions. Often the gas is of an inflammable character, but it is not necessarily of a petroleum origin, and may be any one of several naturally occurring non-petroleum gases. The source of the gas can be determined by careful

A. GLENDON LIMESTONE ON OCMULGEE RIVER, 2 MILES SOUTH OF HAWKINSVILLE, PULASKI COUNTY.

B. INDURATED SAND AND CLAY, ALUM BLUFF FORMATION, MILL CREEK, JEFF DAVIS COUNTY.

chemical analysis only when the gas is of the wet type, containing condensable hydrocarbons. Such gases are commonly considered to be of petroleum origin. Sometimes gas issuing from openings will carry with it particles of mud and sand, thereby building up a cone. These are commonly called mud volcanoes. They are almost always in loose, poorly consolidated material. Sometimes the material is of a plastic character and so seals up the opening. The gas then being collected under some pressure may periodically burst through the covering with more or less violence, thereby resembling a volcano.

Burned shale, or "clinker" as it is often called, may in some cases be indicative of at least past supplies of petroleum. Where the bituminous material has been burned, probably from spontaneous combustion, it may burn the overlying shales, forming clinker. However, such effects are very common in regions where there is lignite or brown coal, due to the burning of the lignite, and should not be given undue importance as an oil indicator.

Salt water springs and "salt licks," as well as springs of sulphur water, are sometimes indications of nearby oil bodies. Oil is very commonly associated with salt water and also with sulphur. However, it should be borne in mind that many non-petroliferous formations contain salt and sulphur, and solutions coming from these need not in any way be evidence of oil.

Structural indications.—In any area where the rocks are of a possible oil-producing character, whether other surface indications mentioned above are present or not, the presence or absence of favorable structural features should be looked for, and their location, extent, and character determined.

Sometimes it is very easy to work out the location and magnitude of structures where good rock exposures are numerous and the structures simple. Very often, however, outcrops are few and poor, structures are complicated and of very low dips, making the task of delimiting them a difficult one. In such cases a very careful sur-

vey is necessary. Often structures must be projected from distant outcrops or even determined in large measure by data from drilled wells.

In the working out of a geologic structure, whether by hand level, alidade, transit, or by well logs, it is essential that some one definite bed or horizon, which can be fairly readily recognized, be taken as a key bed. Then all measurements of elevations are in terms of this key bed and its departures from the horizontal may in general be interpreted as outlining any structure. Often the only data available may be a negative character; that is, there may be an absence of outcrops, well records, or both, and then the lack of exposures at the surface of formations reasonably expected at relatively shallow depths constitutes fairly strong evidence against any uplift. This may be offset by any previous structures having been planed off and then buried beneath horizontal beds, in which case the structure would remain concealed, unless there was movement later than the deposition of the surface material.

Again, it must be borne in mind that the few conditions outlined above by no means wholly cover the selection of the location of a test well, but represent only some of the major considerations and are here given to the extent that they may throw light on some of the succeeding discussions.

While surface indications, such as asphalt and gilsonite deposits, oil seeps, bituminous rocks, etc., are often present, they are by no means universally present in oil fields. In fact, they are the exception rather than the rule. Furthermore, their chief significance probably lies in the fact that they stimulate interest for detailed examination. Such further investigation may lead to the discovery of favorable structures. It then becomes largely a question as to whether or not the major conditions of source, conversion, accumulation, and retention have been fulfilled. Whether or not they have been met must, in the last analysis, be determined by the drill, and even this may fail, for the productive horizons may be so deeply

buried as to be practically impossible to reach by the present-day drilling methods.

POPULAR FALLACIES RELATIVE TO PETROLEUM AND NATURAL GAS

Many popular fallacies concerning the method of locating oil and gas fields are prevalent. To enumerate all of these would be difficult, in as much as many of them are purely local, but some of these erroneous ideas of wider extent are here explained with the hope of discrediting them.

Divining rods, "Doodle bugs," "Wiggle sticks," etc.—One of the common methods used by fake promoters to determine the alleged presence of oil and gas is by the use of divining rods, "Doodle bugs," "wiggle sticks," and other such contrivances. These are of many and varied types but all are based on the assumption that oil and gas are capable of exerting some force on these "detectors" which will cause them to move, bend, rotate, oxidize, change color, or do various other things. Careful study of the principles upon which these contrivances are based and the results obtained by their use, both equally discredit their value as a means of locating oil or gas pools.

General surface appearance.—Another common fallacy is based on the general appearance of a region. Some person, familiar with some oil region, may go into another region of similar appearance and thereby conclude that oil must be present. As a matter of fact surface appearance has absolutely no direct bearing on the presence or absence of oil where such surface appearance is purely a matter of topography, soil color, vegetation etc.

Topography.—A very common mistake made by many persons is the confusing of ordinary hills and ridges with structure. Very often, for example, isolated, round-topped hills are regarded as domes when they are strictly an erosional feature. Hills may, and often do, coincide with structure, but far oftener do not.

Migration of oil.—A common practice among so-called "oil experts" is to plot, on base maps, structural lines connecting widely separated oil fields, or to project such lines long distances from a producing field to show structure in an unstudied region regardless of actually existing conditions. After establishing their desired structures they picture rivers of oil flowing along underground, thereby assuming practically universal extent of formations and incredible migration powers of oil.

As a matter of fact geologic formations are by no means of universal extent. Often times formations of the same age are of wide extent, but that does not mean that they are everywhere of the same character and could permit migration of oil throughout their extent, all other conditions being favorable. Moreover, no such wonderful powers of migration have ever been proven for oil.

More often, however, such "experts" take no account of formations, but attribute to oil the power of migrating any distance, through any kind of rock, or over any type of structure. An example of this is the often-stated reason why oil must exist in southern Georgia. This is based on the theory that the oil has migrated from the Kentucky fields. In this case they do not take into account the distance, the presence of wide areas of igneous and highly metamorphosed sedimentary rocks, and the major structural lines of the area between Kentucky and southern Georgia, but credit oil with powers great enough to overcome all obstacles.

Vegetation.—Various attempts have been made to show a relationship between the presence of oil and gas and certain types of vegetation. Present-day vegetation is primarily the result of existing climate and soil, and it is difficult to see how it could have any connection with deeply buried oil formed in past geologic time. It is conceivable that the presence of certain gases found in some oil fields might have an effect on the vegetation, but none of the

relationships suggested have very wide acceptance among petroleum geologists.

An indirect relationship is often shown in this way: In many areas certain types of vegetation are commonly found where certion formations are at the surface or nearly so. In this way the vegetation may show the presence of certain formations near the surface whose presence there may indicate structure. Thus indirectly vegetation may indicate structure, but it is only related to oil in its bearing on said structural conditions.

Elevations.—The idea is sometimes put forth that no oil is to be expected from beds whose elevation is above sea-level. The fallacy of this can readily be proved by an examination of the data from any oil fields.

"Gas blowouts."—Among many self-styled "oil experts" the so-called "gas blowout" is considered excellent evidence of the presence of oil or gas. Mud volcanoes might will be termed "gas blowouts," but what are generally called "blowouts" are not of the mud volcano type but represent effects generally produced by erosion or by chemical action.

One type of the so-called "blowout" is the isolated rock outcrop in regions generally covered by loose mantle rock or soil. The outcrop is said to have been blown out and broken by the gas pressures from the underlying oil and gas pools. As a matter of fact such "blowouts" are not known to exist unless the rocks have been forced up by igneous action, in which case the action is certainly not the result of natural gas pressure. These isolated outcrops are the normal result of erosion, the harder portions of the rock being more resistant, thereby being left exposed after the softer portions have been eroded away.

Another type of "blowout" is said to be proven by the presence of rocks having a burned or blackened appearance. Very often these supposedly burned rocks are high in iron and manganese oxides, the iron and manganese salts having been deposited from

solution, with accompanying oxidation. In very arid regions the burned appearance may be due to desert varnish on the rocks. That is, the intense heat of the sun has caused the salts within the rocks to be brought to the surface, where they produce the dark staining.

A third commonly called "gas blowout" is the lime sink. This is the direct result of the caving in of the surface, caused by the collapse of underground caverns formed by the removal of limy material in solution.

Other types of the so-called "gas blowouts" might be enumerated, but it is probably sufficient to say that the term "gas blowout" as commonly used is entirely erroneous and has no significance as related to oil or gas production.

HISTORY OF OIL PROSPECTING IN GEORGIA

In 1919 the Georgia Geological Survey, in a report entitled "A Preliminary Report on the Oil Prospect near Scotland, Telfair County, Ga.," outlined a history of oil prospecting in Georgia to that date. The following record is taken largely from the above report, slightly modified and supplemented, bringing it up to the present date.

The pioneer deep test of the Coastal Plain of Georgia was made by the late Capt. A. F. Lucas, whose fame in connection with early production near Beaumont, Texas, is well known. Capt. Lucas in 1905 drilled at a point about three and a half miles southwest of Louisville, in Jefferson County. The location was made mainly with reference to apparent oil seeps. Drilling difficulties were encountered at about 500 feet, and the well was shut down until two years later, when it was taken over by the Georgia Petroleum Oil Co., who carried it down to the crystalline rocks, at 1143 feet, without commercial production.

Soon after Lucas began the Louisville test well another test was started near Doctortown, in Wayne County, and carried to 1901 feet. Some gas was reported below 500 feet but no quantity of either oil or gas was encountered.

In 1908 a test was made near Hazelhurst, by the Hinson Oil, Gas and Development Co. This well is reported to have been sunk to about 985 feet and shot with dynamite, which bridged the hole and badly damaged the casing. A barrel or more of crude oil is said to have been bailed out after the shot, but it seems that the well was never cleaned out to continue the test.

The deepest hole ever drilled in the Coastal Plain of Georgia is at Fredel, ten miles south of Waycross, drilled in 1915 by the Waycross Oil and Gas Co. in an unsuccessful attempt to get production. Showings of oil and gas were reported at about 1000 feet.

Not long after the Fredel project was started a great deal of leasing was done in the Chattahoochee and Withlacoochee River areas. This activity was caused by reference in a State report on the geology of the Coastal Plain to hypothetical anticlines indicated by stream data. Only one shallow test is known to have been made, however, and this apparently failed to encourage further drilling.

In 1919 a test well was drilled to about 830 feet, at a point about 9 miles northwest of Fitzgerald, without encountering production.

In 1920 the Middle Georgia Oil & Gas Co., drilled about 12 miles northwest of Sandersville, reaching the basement crystalline rocks at a little less than 400 feet. The same company later began a test in Jeff Davis county about 15 miles west of Hazelhurst. This operation is temporarily shut down at 1975 feet.

At about the same time the Middle Georgia Oil & Gas Co. was making the Sandersville test a well was being drilled at Cherokee Hill about 6 miles northwest of Savannah. A depth of about 2130 feet was reached and showings of oil and gas reported but no production was obtained.

In the summer of 1921 the Three Creeks Oil Company drilled at Allens Station, about 9 miles south of Augusta, reaching the basement crystalline rocks at about 400 feet. The company then moved

their rig to a point in Burke County about two and a half miles east of Green's Cut, where they are temporarily shut down at about 1000 feet[1]. This is the only known test well in the State that is drilling at the present time, except the Dixie Oil Company's well near McRae in Wheeler county.

In addition to the enumerated test wells in the Coastal Plain several attempts to secure oil production have been made in North Georgia. In 1902 the Rome Petroleum and Iron Co. drilled two wells, 1200 feet and 1850 feet deep, respectively, in the Paleozoic area near Rome. Several years later an 1100 foot test was made in the crystalline rocks near Madison.

All drilling in Georgia has so far failed to result in commercial production.

PHYSIOGRAPHIC FEATURES OF GEORGIA[2]

PHYSIOGRAPHIC DIVISIONS

The State of Georgia is divided into five well-marked physiographic divisions, namely, the Coastal Plain, the Piedmont Plateau, the Appalachian Mountains, the Appalachian Valley, and the Cumberland Plateau. Each of these divisions is comparatively well defined; nevertheless, in some instances, the line of separation can not always be sharply drawn. Often, in places, one division blends with another, so that it is frequently impossible to give definite boundaries. In such cases the boundaries can only be spoken of as occurring within certain limits.

The physiographic divisions of the State, above enumerated, are not peculiar to Georgia alone. They form a part of the main topographic provinces of the Eastern division of the United States, which have been described, under the names here given, by Hayes[3] and others. As a whole these divisions may be spoken of as certain well-marked land forms, composing belts or zones of varia-

---

[1]Later, the test well here referred to was abandoned and another was put down in the same vicinity, which encountered crystalline rock at about 1002 feet.

[2]Reprinted, with exception of section on Coastal Plain, from description by S. W. McCallie, in Georgia Geol. Surv. Bull. 15, pp. 23-27, 1908.

[3]U. S. Geol. Survey, Nineteenth Ann. Rept., 1897-98, pp. 9-58.

ble width extending from New York to Alabama. Each division has its own topographic peculiarities and constitutes a distinct physiographic type. They all have a southwesterly trend, and traverse the various States between the limits mentioned. The surface configuration of Georgia, as represented by the physiographic divisions above enumerated, is here described in detail.

COASTAL PLAIN[1]

General features.—The Coastal Plain of Georgia embraces all that portion of the State that lies south of the Piedmont Plateau region. It has an areal extent of approximately 36,000 square miles. The line of contact between the Piedmont Plateau and the Coastal Plain is an irregular line, known as the "Fall line." It extends from Columbus on the west through Macon and Milledgeville, to Augusta on the east. The Fall line derived its name from the small falls or rapids which mark the places where the streams leave the more steeply sloping crystalline rocks of the Piedmont region and pass onto the softer rocks of the Coastal Plain.

Physiographically the region is a low plain having a gentle southward slope. In comparison with the other physiographic divisions of the state this plain has been subjected to erosion for only a short time, and its topography over the greater part of the area may be described as youthful. On the whole the Coastal Plain is level, although it comprises some hilly and broken areas in the northern part near the Fall line, where in places it is dissected and appears somewhat more mature. None of the hills, however, rise above a general level, and their tops present an even skyline. The rocks are mainly unconsolidated sands, clays, and marls of simple structure, and the region consequently lacks the pronounced topography due to resistant varieties of rock and the folding of beds that characterize the Appalachian Valley and the Appalachian Mountains. The plain reaches a maximum elevation above sea level of 650 to 700 feet between Macon and Columbus, and of 500 to 600

[1]In large part reprinted from Stephenson, L. W., and Veatch, J. O., "Underground Waters of Georgia," U. S. Geol. Survey Wat. Sup. Paper, pp. 28-38, 1915.

feet between Macon and Augusta, and thence slopes 3 to 4 feet per mile to sea level. About half of the plain is less than 300 feet, and a large area near the Atlantic coast, about one-seventh of the total, is less than 100 feet above sea level. Here the streams have

MAP I SHOWING PHYSIOGRAPHIC DIVISIONS OF GEORGIA

not cut as deep courses as in the older divisions, tributary streams are fewer, and large, flat, undrained or poorly drained areas abound, particularly in the southeastern part.

Although the Coastal Plain may be described, in comparison with the Appalachian Valley, Appalachian Mountains, and Piedmont Plateau, as a plain, it is not entirely featureless, and within itself it presents topographic contrasts. It may be divided into six physiographic subdivisions—the Fall-line hills, Dougherty plain, Altamaha upland, Southern lime-sink region, Okefenookee plain, and Satilla coastal lowland.

Fall-line hills.—The Fall-line hills, as is indicated by their name, occupy the upper portion of the Coastal Plain, their northern boundary being approximately the Fall-line, south of which the hills form a belt 40 to 50 miles wide across the State. This belt, however, is not sharply defined, for on the north it merges into the Piedmont Plateau and on the south into the level and less broken land of the Dougherty plain and the Altamaha upland. In the Fall-line hills, more than in any other subdivision of the Coastal Plain, the topographic features are due to surface erosion. Stream erosion is more active because of the greater altitude, and it has been going on for a longer period of time. The region is characterized by flat-topped hills or ridges and deep gullies or ''washes.'' The larger streams have cut courses 200 to 350 feet below the level of the upland plain, and the northern portion of the belt is as broken as the adjacent Piedmont Plateau. The region is underlain mainly by sands and clays of Cretaceous and Eocene age, and their softness has favored rapid erosion.

In elevation above sea level the higher land west of Ocmulgee River varies from 350 to 700 feet; that east of the Ocmulgee from 300 to 600 feet. The elevations of low water at Columbus, Macon, Milledgeville, and Augusta are, respectively, 200, 279, 241 and 109 feet.

Two types of hills are commonly recognized, the sand hills and the red hills. The sand hills are best developed in the northern portion of the belt. They are essentially flat ridges, with from 3 to 30 feet of covering of loose, gray to brownish quartz sand, which is probably residual from the underlying material. The red hills are the more common in the southern part of the Fall-line belt. The soil of the hills is a bright red sand or red sandy loam, and is residual from the underlying formations.

Dougherty plain.—The Dougherty plain occupies a large area in the western part of the Coastal Plain, extending from the Chattahoochee river to a few miles east of Flint river, where it is rather sharply separated from the Altamaha upland by the escarpment formed by the north-western limit of the Alum Bluff formation. It includes all or the greater part of the counties of Decatur, Seminole, Miller, Mitchell, Early, Baker, Calhoun, Dougherty, Randolph, Terrell, Lee and Sumter. A small strip extends eastward from the Flint to the Oconee, including parts of Dooly, Houston, Pulaski and Laurens counties. The plain is characterized by very level tracts, containing few elevations that can properly be termed hills. Small streams and branches are comparatively few, and surface erosion is consequently slight, the drainage being in large measure subterranean. The surface is further characterized by numerous lime sinks, which vary in size from small depressions, with diameters of from 100 to 200 feet, to hollows occupying several hundred acres and to chains of sinks several miles in length. The sinks usually contain shallow ponds or lakes.

The main topographic features of the Dougherty plain have resulted from the rapid removal in solution of the calcareous materials of the surface or near-surface formations. The elevation above sea level of the Dougherty plain varies from approximately 125 feet in Decatur County to 450 feet in the southern part of Houston County, much the greater portion being less than 300 feet.

Altamaha upland.—The Altamaha upland constitutes the largest physiographic subdivision of the Coastal Plain. Its northern boundary runs irregularly between Waynesboro, Tennille, Dublin, Cochran, and Vienna, and its western edge lies parallel to and a few miles east of Flint River as far south as Decatur County. On the southeast, in Effingham, Liberty, Wayne, Pierce, Ware, and Clinch counties, it merges into the sandy pine flats of the Okefenokee plain. The division embraces most of the region popularly known as the "wiregrass country," and is underlain by the Alum Bluff formation, and by the weathered residual products of that formation or by younger material of similar lithology.

The region can be called an upland only in comparison with the low coastal plain on the southeast and the adjacent Dougherty plain on the west; on the whole it is lower than the Fall-line hills to the north. It varies in elevation above sea level from about 470 feet in the north and west to about 125 feet in the southeast, there being a gradual slope to the southeast.

Characteristic of the topography are low rolling hills with smooth or softened outlines, which, except along the large rivers, do not rise more than 40 or 50 feet above the valleys. None of the features suggest ruggedness, yet at the same time the region is not monotonously level or flat.

Streams are much more numerous than on the Dougherty plain and the coastal flats. Altamaha, Ocmulgee, and Oconee rivers have cut valleys 100 to 150 feet deep, bordered in a few places by precipitous bluffs, where the surface rocks are locally more resistant, but except for these the valleys are shallow. Those of the small streams have low breastlike slopes and may be described as dish shaped. The creeks flow through broad swampy bottoms, are generally sluggish, and are characterized by clear water, free from sediment, in contrast to the muddy waters of the Ocmulgee, Oconee and Altamaha.

In the southeastern part of the Altamaha upland the land is more level and finally merges into the moist pine flats of the Okefenokee plain. Throughout this part small cypress ponds are numerous, the valleys of the small streams are more swampy, and the streams themselves have banks not more than a foot or two high. Along the northern and western edges of the Altamaha upland in Screven, Wilcox, Crisp, Turner, Worth, and Decatur counties, sinks, due to the underground solution of limestone, are present.

The soil is generally sandy and the country in places is thickly mantled with loose gray sand. In many places, though more notably in the northern half, are considerable exposures of the indurated clays and sands of the Alum Bluff formation. Many of the streams and creeks are bordered by sand hills made up of loose, gray, yellow, or light-brown, quartz sand. These sand belts normally parallel the streams and rarely exceed two miles in width. The origin of these sand hills is not yet well understood.

In comparison with the Dougherty plain, the Altamaha upland has a rolling topography, more numerous streams, and fewer lime sinks. It is not so entirely featureless as the swampy tracts along the coast and is better drained. In contrast to the Fall-line hills it lacks ruggedness, and its valleys are shallower.

Southern lime-sink region.—The Southern lime-sink region occupies a small area in the southern part of the state, embracing the southeastern part of Decatur County, the southern halves of Grady, Thomas, Brooks, and Lowndes counties, and adjacent areas in Florida. The topography is hilly and is characterized by lime sinks, lakes, and ponds.

The surface varies from 150 to 275 feet above sea level, and the hills rise 50 to 75 feet and in a few places 100 feet above the valleys. The topography is more rugged than that of the adjacent Altamaha upland and the Dougherty plain, this difference, and other characteristics of the subdivision being due mainly to the differences in the underlying geologic formations. The lime sinks are due to the under-

A. INDURATED SAND AND CLAY, ALUM BLUFF FORMATION, MILL CREEK, JEFF DAVIS COUNTY.

B. WORKING FACE, TIFT HILL SAND PIT, EAST SIDE OF FLINT RIVER, ALBANY.

ground solution of upper Oligocene limestone, which, except in small areas, is not the surface material, but which is overlain by 50 to 100 feet of sand and clay, whose soft and easily eroded character probably accounts for its greater ruggedness as compared with the western lime-sink region (Dougherty plain). The lakes and ponds occupy depressions caused by the collapse of underground solution caverns in limestones. Some of the lakes cover areas of several hundred acres and are free from timber growth, but the smaller and shallower ponds support a thick growth of cypress. The water in these sinks varies with the seasons, but is known suddenly to disappear or to rise, owing probably to the opening or closing of underground passages.

The drainage, as in the Dougherty plain, is to some extent subterranean, and small streams are not numerous. The rivers of the region, the Ocklocknee, the Withlacoochee, and other smaller streams, flow canal-like through broad sand-covered terrace plains. The waters of the streams are not muddy but are dark on account of dissolved and suspended organic matter; that of the lake is clear.

The soil is in many places red sandy clay. Superficial gray sand, such as characterizes the Altamaha upland, is not so widely distributed. The tree growth differs somewhat from that of the wiregrass region to the north, some oak and hickory being associated with the long-leaf pine.

Okefenokee plain.—The Okefenokee plain forms a north-south belt 20 to 40 miles wide in the southeastern part of the Coastal Plain, including parts of Effingham, Bryan, Liberty, Wayne, Pierce, Camden, Ware, Charlton, Clinch, and Echols counties. On the west it is bounded approximately by a line extending from the northeast corner of Effingham county southwestward nearly to Groveland, Bryan County, thence to a point a few miles south of Glenville, thence nearly to Jesup and Waycross, and thence along the western boundary of the Okefenokee Swamp. The escarpment separating the plain from the Altamaha upland is poorly defined, and in

places the two seem to merge. On the east the plain is separated from a lower coastal terrace by an abrupt descent or escarpment.

The Okefenokee plain is essentially a featureless sandy flat, in which there are few streams and many cypress and gum ponds and swamps, whose areas range from a few acres or a few square miles to the immense expanse of the Okefenokee Swamp. It thus presents a contrast to the rolling topography and dendritic drainage of the Altamaha upland. The Okefenokee plain varies in elevation above sea level from about 60 to perhaps 125 feet, sloping eastward about 2 feet to the mile. The drainage is poor, at least 25 per cent of the area being swampy, and the few creeks and branches flow through broad swampy flats only slightly lower than the general level. At only a few places are the bluffs as high as 30 or 40 feet. The flatness of the plain and its swampy condition are due to the newness of the land surface, the retreat of the sea having taken place in comparatively recent geologic time, to the low altitude, and to the fact that the surface formation is a thick, loose, porous sand which absorbs the rainfall and hence lessens surface erosion. The streams are sluggish, and their waters, except those of the Altamaha and Savannah, are black or coffee-colored from organic matter. The region is characterized by moist long-leaf pine and saw-palmetto flats, cypress ponds, gallberry flats, and swamps supporting thick growths of gum and bay.

Satilla coastal lowland.—The Satilla coastal lowland or Satilla plain is a low marine terrace 20 to 35 miles wide that borders the Atlantic Ocean and includes part or all of the counties of Chatham, Bryan, Liberty, McIntosh, Glynn, and Camden. The western edge is marked by a rise of 20 to 40 feet, probably a Pleistocene shore line, which is prominent at Walthourville, Mount Pleasant, and Waynesville, and a short distance east of Folkston.

The greater part of the plain is 15 to 25 feet above sea level, but in a few places it reaches an elevation of about 40 feet. It has a slight eastward slope, somewhat difficult to estimate but generally

less than a foot to the mile. Although the plain is low, flat, and poorly drained it presents several different topographic aspects. It differs from the Okefenokee plain chiefly in its lower altitude, in its greater area of swamp and inundated land, and in its topographic forms, which are incident to low coast land.

The western part of the belt is on the whole a sandy flat plain containing an open growth of long-leaf pine. Numerous small cypress ponds and large swamp areas abound. Near the coast the plain presents a different aspect. Owing to recent submergence the coast line is irregular, and a network of sea islands, tidal rivers, sounds, estuaries, and marshes has been formed. The land terminates as beach on sea islands, as sand bluffs not more than 10 or 15 feet above low tide, and as marshes at the mouths of the rivers. The islands are sand covered, and some of them exhibit sand dunes, which, however, nowhere reach great magnitude.

The tree growth of the coast land is characterized by the cabbage palmetto and live oaks, which are more abundant than farther west.

There are two classes of swamp land, upland and tidal. Swamps of the upland class, of which Buffalo Swamp, in the western part of Glynn County, is representative, probably occupy the sites of former shallow sounds or coastal lagoons and marshes which have become land through uplift and retreat of the sea, and which have not been inundated as a result of later subsidence indicated by drowned-river courses. Other upland swamps are apparently once more becoming lagoons, for the subsidence seems to be still going on and the sea to be slowly encroaching on the land. The best proof of this is the presence of tree stumps, and even dead standing trees, in brackish water marshes.

The second class, the tidal swamps, occur in considerable areas along Savannah, Ogeechee, Altamaha, Satilla, and St. Mary's rivers. They differ from salt marshes chiefly in that at high tide they are partly covered by the backing up of the fresh river water, instead

of directly by the sea. They extend up the rivers 10 to 20 miles beyond the salt marshes.

The salt marshes reach their greatest extent at the mouths of the rivers, being caused mainly by subsidence of the coast, though silting of the low areas by the streams has doubtless been a factor.

The Satilla plain is poorly drained, owing to the newness of the land surface and its low altitude. The few streams are sluggish, and with the exception of the Savannah and Altamaha rivers the waters are dark or even black from organic matter. Most of the streams flow eastward or southeastward, their courses having been determined by the general slope of the plain. Satilla and St. Mary's rivers, however, in parts of their courses flow parallel to the coast—that is, at right angles to the terrace slope.

PIEDMONT PLATEAU

The Piedmont Plateau is a wide belt, or zone, of elevated land, stretching from the foot of the Appalachian Mountains to the Coastal Plain. Its northern limit is an ill-defined line, extending from the extreme northeastern corner of the State to the Georgia-Alabama line, a few miles southeast of Cedartown. It traverses the State from the northeast to the southwest, with an average width of more than 100 miles, and comprises an area of something like one-third of the total area of the State. This physiographic division consists of an old land form, which has been reduced by erosion to a peneplain. Along its northern boundary it has an average elevation of about 1,200 feet above sea level, while at its junction with the Coastal Plain it is reduced to a little less than half of this elevation. It has, therefore, a slope to the southward of about 5 feet per mile, or about twice the slope of the Coastal Plain.

The Piedmont Plateau, when viewed from an elevated point, has the appearance of a level plain, dotted here and there with isolated mountains and hills, such as Stone Mountain, Kennesaw Mountain, and Pine Mountain, which rise from 500 to 800 feet

above the general level of the Plateau, and which appear to be remnants of an older and somewhat different topography.

The minor inequalities of the surface of the Piedmont Plateau are entirely overlooked, or minimized, by a view from an elevated point. The region, instead of being a level plain, has a broken surface, made up of low, well-rounded hills and ridges, separated by narrow fertile valleys. These minor hills or ridges, which usually have a southwesterly trend, have an elevation varying from 200 to 300 feet above the stream level.

The streams of the Piedmont Plateau are usually rapid, and are frequently marked by cataracts and water-falls. This feature of the streams is especially accentuated along the margin of the Coastal Plain. The river valleys, which are being continually increased in depth by the erosive action of the streams, rarely ever exceed a width of more than a few thousand yards.

APPALACHIAN MOUNTAINS

This physiographic division is located in the northern part of the State, along the Georgia-Tennessee line, and extends as far south as Cartersville, the county site of Bartow County. It has a somewhat triangular form, being limited on the south by the Piedmont Plateau, and on the west by the Appalachian Valley. The western boundary may be said to correspond with what is known as the Cartersville fault, a great displacement marking the boundary between the metamorphic and the sedimentary rocks in the northwestern part of the State. This division embraces all, or a part of the following counties: Rabun, Towns, Lumpkin, Union, Fannin, Gilmer, Pickens and Bartow. It is one of the smallest of the five topographic divisions of the State; nevertheless it comprises an area of more than 2,000 square miles.

This division forms the southern terminus of the Appalachian Mountains. It is preeminently a mountain region, noted for its picturesque scenery and lofty mountains. The average elevation of

the region is less than 2,000 feet, yet there are numerous mountains within the area attaining an altitude of more than twice this height. The larger mountains occur in groups or masses without definite arrangement. The higher peaks of these groups usually have precipitous slopes, which, in plaees, become almost inaccessible. The lesser mountains, and the ridges of the region generally, have a southwesterly trend, corresponding to the general course of the streams. The valleys are narrow and are traversed by rapid streams which, in places, form falls many feet in height. Between the main mountains and the ridges there is a large area of broken country, with hills rising 400 to 500 feet above the general stream level. This portion of the division resembles very closely the more hilly parts of the Piedmont Plateau.

APPALACHIAN VALLEY

The Appalachian Valley may be defined as a low land, lying between the Appalachian Mountains and the Cumberland Plateau. This physiographic division, which traverses the northeastern corner of the State in a southwesterly direction, is about 35 miles wide, and it has an average elevation of about 850 feet above sea level. Its western boundary is an irregular line, following the eastern escarpments of Pigeon and Lookout mountains.

The region is made up of a number of minor valleys, separated from each other by sharp or by well-rounded ridges. The former ridges as in the case of Taylor's ridge and Chattooga Mountain, often attain an altitude of 1.500 feet, while the latter rarely reaches a height of more than 1,200 feet. These ridges all have a northeast-southwest trend, and give to the region a corrugated appearanee. The minor valleys are usually narrow and are traversed by rather sluggish streams. which in the northwestern part of the area flow north into the Tennessee River, while those in the other parts of the area flow southward to the Gulf of Mexico.

CUMBERLAND PLATEAU

The Cumberland Plateau occupies the extreme northwestern corner of Georgia, and embraces Pigeon Mountain and portions of Lookout and Sand mountains. This physiographic division of the State constitutes the extreme eastern margin of the Cumberland Highlands, traversing Alabama and Tennessee further to the westward. Broadly speaking, the area is an elevated tableland, bisected longitudinally by a deep, narrow valley. That part of the area lying east of the valley constitutes Lookout and Pigeon mountains, and that to the west Sand Mountain. These mountains have broad, flat tops, with an average elevation of about 1,800 feet above sea level. The slopes of the mountains are always precipitous, and are often marked by bold sandstone cliffs, which in some places attain a height of 200 feet.

Lookout Mountain as it enters Georgia from Alabama forms a broad, flat-top mountain, about 10 miles in width. Some 6 or 8 miles north of the State line the mountain sends off to the northward a spur known as Pigeon Mountain. From this point to its northern terminus in the vicinity of Chattanooga it varies in width from 2 to 4 miles. Some of the small streams. which take their rise on Lookout, in their descent to the valley below have cut deep and precipitous chasms in the sandstone bluffs which form the brow of the mountain. Sand Mountain, as represented in Georgia, differs from Lookout Mountain mainly in being broader and in having a more even surface. The valley above referred to as bisecting the Cumberland Plateau region of Georgia is the only valley occuring in this physiographic division. It has an average width of about 3 miles and is traversed by Lookout Creek, a sluggish stream, of considerable size, flowing north into the Tennessee River. The surface of the valley is rolling, but at the same time it has a general slope to the northward.

GEOLOGY OF THE COASTAL PLAIN OF GEORGIA

GEOLOGIC FORMATIONS

The geologic formations of the Coastal Plain of Georgia range in age from Cretaceous (Probably Lower Cretaceous) to Recent. The areas of outcrop of the formations are in more or less parallel belts or bands, the older formations passing beneath the younger as we proceed toward the present coast. There follows a table of these formations and a description of each one.

Era	System	Series	Group	Formation	Member	Thickness
Cenozoic	Quarternary	Recent				
		Pleistocene	Columbia	Satilla formation		50
				Okefenokee formation		20—50
	Tertiary	Pliocene(?)		Charlton formation		?
		Miocene		Duplin Marl		10—15
				Marks Head marl		45±
				Alum Bluff formation		350±
		Oligocene		Chattahoochee formation		100±
			Vicksburg	Glendon formation		100±
		Eocene	Claiborne	Ocala ls. / Barnwell formation	Sand and marl / Twiggs clay	300±
				Undifferentiated Claiborne to west | McBean formation in east Ga.		200±
				Wilcox formaton		75—100
				Midway formation		200—400
Mesozoic	Cretaceous	Upper Cretaceous		Ripley formation	Providence sand Marine beds Cusseta sand	900±
				Eutaw formation / Undif. Upper Cretaceous	Tombigbee sand	
					Lower beds	550±
		Lower Cretaceous		Lower (?) Cretaceous		375 ?

CRETACEOUS SYSTEM

Immediately south of the Fall line is a belt of sands, clays, and marls varying in width from about 5 to 35 miles and extending southwestward across the state from Augusta, through Macon, to Columbus. These deposits rest unconformably on the old crystalline basement rocks, from which their lower part was obviously derived. They are overlain unconformably by beds of unquestioned Eocene age.

In the area adjacent to Chattahoochee River the lower part of these deposits consists of arkosic, micaceous, crossbedded sandy clays and gravels probably of Lower Cretaceous age, which were probably laid down in shallow non-marine water. Materials of this character extend into Alabama, where they are well developed as far west as Alabama River. They are traceable toward the northeast for a distance of about 25 miles, where they pinch out and disappear against the crystalline rocks of the Piedmont Plateau. These older non-marine beds are unconformably overlain in the Chattahoochee River area by interbedded gray calcareous sands and calcareous clays or marls of marine origin (Eutaw and Ripley formations), some layers of which carry well-preserved Upper Cretaceous fossils. Toward the northeast these marine strata first intertongue with and finally merge completely into irregularly bedded sands and clays of shallow-water origin, which in this report are called undifferentiated Upper Cretaceous deposits.

The Cretaceous of this region, as adapted from Stephenson[1] and others, is subdivided as follows:

Series	Formation	Member	
Upper Cretaceous	Ripley	Providence sand Marine beds Cusseta sand	?
	Eutaw	Tombigbee sand Lower beds	Undifferentiated Upper Cretaceous
Lower Cretaceous	Lower Cretaceous (?).		

[1] Stephenson, L. W., U. S. Geol. Survey Prof. Pap. No. 81, pp. 19 et seq., 1914.

LOWER CRETACEOUS (?) UNDIFFERENTIATED

The strata in the vicinity of Columbus previously referred to as probably of Lower Cretaceous age outcrop along Chattahoochee River approximately from Columbus to the mouth of Upatoi Creek, a distance of about 9 miles. The area narrows to the east and terminates in a point near Geneva, about 25 miles east of Columbus, where the overlying Eutaw rests on the crystallines. The beds consist of about 375 feet of micaceous, cross-bedded sands, clays and gravels. They were derived from decomposed crystalline rocks and have been transported only a very short distance from their source. The beds rest unconformably upon crystalline rocks.

The unconformity mentioned between these beds and the overlying definitely recognized Eutaw would seem to indicate their pre-Eutaw age, and if the older beds are really of Lower Cretaceous age the unconformity is of considerable time significance.

These non-marine beds have thus far failed to yield any well-preserved fossils in Georgia. On the basis, however, of their apparent relation to beds of more or less definite Lower Cretaceous age farther west in Alabama they have been referred to the lower Cretaceous by Stephenson[1], Berry[2], and others.

EUTAW FORMATION

The Eutaw formation is exposed in western Georgia in a triangular area 10 miles wide along Chattahoochee River below the mouth of Upatoi Creek, but narrowing eastward and merging into the lower part of the undifferentiated Upper Cretaceous deposits. In the Chattahoochee River valley it rests with unconformity on the supposed Lower Cretaceous. At its outcrop the formation consists mainly of more or less fossiliferous, marine, dark-colored sands and clays, which are partly calcareous and attain a thickness of about 550 feet. Stephenson recognizes a lower or basal member and an upper or Tombigbee sand member.

---

[1]Stephenson, L. W., U. S. Geol. Survey Prof. Paper 81, p. 10, 1914.
[2]Berry, E. W., U. S. Geol. Survey Prof. Paper 112, p. 7, 1919.

RIPLEY FORMATION[1]

The Ripley formation outcrops over a northeast-southwest belt in western Georgia extending from the Chattahoochee River, where it is about 15 miles wide, eastward to the Flint River. It rests with apparent conformity upon the Eutaw formation in the Chattahoochee River valley, and merges into the undifferentiated Upper Cretaceous farther eastward. In general the formation is marine and comprises dark-gray to green, fossiliferous sands, clays, and impure limestones. The total thickness of the Ripley in the region of its outcrop is thought to be about 900 feet. Members designated as the Cusseta sand and the Providence sand are recognized. In the Flint River valley the deposits merge with more or less intertongueing into the undifferentiated Upper Cretaceous deposits.

UPPER CRETACEOUS UNDIFFERENTIATED

Eastward from the Flint River valley, in a belt with a maximum width of about 35 miles, paralleling the Fall line and extending across the State, are the deposits referred to as undifferentiated Upper Cretaceous. The terrane consists of arkosic and micaceous sands, gravels, and clays, which were laid down in shallow water swept by chaotic currents. Commercial deposits of kaolin and gravel are common. The material evidently was removed from the weathered, highly kaolinized surface of the ancient crystalline rocks by rather sudden rejuvenation of drainage. These deposits are probably of Eutaw and Ripley age. They rest unconformably on the crystallines, are overlain unconformably by the Eocene in eastern Georgia, and grade into the Eutaw and Ripley formations in western Georgia, reaching a maximum thickness of about 600 feet.

The lower part of these undifferentiated deposits has in previous reports by Stephenson, Berry, and others been regarded as Lower Cretaceous in age and as corresponding to the "Hamburg" of Sloan

---

[1]Stepheson, L. W., Geol. Survey Prof. Pap. No. 81, p. 21, 1914.

in South Carolina and to the somewhat more definitely believed Lower Cretaceous of Alabama. In recent field work in Aiken County, S. C., however, Dr. C. W. Cooke found no evidence which warrants separating the "Hamburg beds" of Sloan, of the so-called Lower Cretaceous, from the overlying Middendorf, which has been shown by Berry[1] and others to be of Upper Cretaceous age. Thus in the absence of paleontologic evidence to the contrary the "Hamburg beds" of western South Carolina and their apparent southwestward extension represented by the so-called Lower Cretaceous of eastern Georgia are probably of Upper Cretaceous age.

TERTIARY SYSTEM

EOCENE SERIES

MIDWAY FORMATION[2]

Areal distribution.—The Midway formation has a relatively small areal extent. It outcrops in a belt having a general northeast-southwest direction, and extending from Fort Gaines on the Chattahoochee River to Montezuma on the Flint River, and from Montezuma north and northeast into Houston County as far as the Perry branch of the Central of Georgia Railway. The areal width of outcrop of the formation on the Chattahoochee River is about 8 miles, on the Flint about 15 miles, and between these two rivers averages 8 to 10 miles.

Stratigraphic position.—The Midway formation rests unconformably upon the Upper Cretaceous. Exact contacts between the two are difficult to find because of scarcity of exposures and the lithologic similarity between the basal Midway and the upper beds of the Upper Cretaceous.

Along the Chattahoochee River at Fort Gaines the Midway formation is separated from the overlying Wilcox by a sharp unconformity. In places the formation is overlain by loose sands, and along the Chattahoochee and Flint rivers by terrace deposits probably of Pleistocene age.

[1]Berry, E. W., U. S. Geol. Survey Prof. Paper 112, p. 7, 1919.
[2]After Stephenson, L. W., and Veatch, Otto, U. S., Geol. Survey Water-Supply Paper No. 341, pp. 67-70, 1915.

Lithologic character and thickness.—The Midway formation is principally marine. It consists of sands, clays, marls, and limestones, with occasional thin flint beds. The sands are vari-colored, though often gray and drab. The limestones are usually hard, arenaceous, and highly fossiliferous. The clays usually occur in massive white lenses. The marls consist mainly of quartz sand, clay, glauconite, and shells. Fullers earth occurs at places. The sands and clays make up the greater part of the formation. The thickness of the formation may be as great as 400 feet along the Flint River. Along the Chattahoochee the thickness is probably in the neighborhood of 200 feet.

WILCOX FORMATION[1]

Areal distribution.—The Wilcox formation is of very limited areal extent. It outcrops as a belt with a northeast-southwest trend from Fort Gaines on the Chattahoochee River to the Flint River in Sumter County. The width of the outcrop probably averages 5 or 6 miles.

Stratigraphic position.—The Wilcox formation embraces the strata lying between the Midway and Claiborne formations. Along the Chattahoochee River it rests unconformably on the Midway formation. East of the Chattahoochee River satisfactory contacts between the Midway and Wilcox are very scarce, making an exact line of separation difficult to place.

The Wilcox formation is overlain by the Claiborne deposits. Where observed the contact is marked by an undulatory line of pebbles of coarse material, but shows no pronounced physical evidence of any considerable time interval between the deposition of the two formations.

Lithologic character and thickness.—The Wilcox formation varies considerably from place to place. Along the Chattahoochee River it consists chiefly of dark, laminated, often lignitic, sandy clay, in places consolidated to mudstone; sandy, glauconitic shell marl; and

[1]After Stephenson, L. W., and Veatch, Otto, U. S. Geol. Survey Water-Supply Paper No. 341, pp. 70-73, 1915.

dark, lignitic, argillaceous sand. In Randolph County west and north of Cuthbert the formation in places resembles fuller's earth, and in other places seems to consist largely of vari-colored, somewhat kaolinic sand. In places in Webster County the formation is gray to drab, laminated, glauconitic clay and sand. To the east in Schley and Macon counties, it appears to be made up of red to white sands with massive beds of white clay.

The exact thickness of the Wilcox formation is not definitely known. At Fort Gaines it probably does not exceed 75 feet. At Peterson Hill, northwest of Cuthbert 4½ miles, about 100 feet of the strata are exposed.

CLAIBORNE GROUP[1]

Formations and areal extent.—The Claiborne group in Georgia is represented by the McBean formation and undifferentiated Claiborne deposits. The McBean formation outcrops in the extreme northeastern corner of the Coastal Plain, along McBean Creek, Spirit Creek, Little Spirit Creek, and for a short distance along the Savannah River. The undifferentiated Claiborne deposits outcrop as a narrow irregular strip extending from the Chattahoochee River below Fort Gaines northeastward to the Flint River, along which it outcrops for a few miles in Sumter and Dooly counties.

MCBEAN FORMATION

Stratigraphic position.—The McBean formation rests unconformably upon the Upper Cretaceous strata, and is in turn overlain by the Barnwell formation, from which it is probably separated, at least locally, by an unconformity. It is overlapped by the Barnwell formation.

Lithologic character and thickness.—The McBean formation is made up chiefly of gray marl or sandy limestone, and yellow sand, with a small amount of lignitic material and greenish clay. The greatest observed thickness does not exceed 80 feet.

[1]After Cooke, C. W., and Shearer, H. K., U. S. Geol. Survey Prof. Paper 120-C, pp. 49-51, 1918.

UNDIFFERENTIATED CLAIBORNE DEPOSITS

Stratigraphic position.—Between the Chattahoochee and Flint rivers the Claiborne rests unconformably upon the Wilcox formation. Erosion unconformities have been noted at Fort Gaines and near Cuthbert. The Claiborne deposits are overlain unconformably by red argillaceous sand of undetermined age, from which they are not readily distinguished lithologically.

Lithologic character.—The best exposures of the Claiborne are along Chattahoochee River at Fort Gaines and in the Danville Ferry Bluff on the Flint River, 16½ miles east of Americus. In the Fort Gaines area the strata consists of gray to drab sand and clays, in part calcareous, claystone, and clay somewhat resembling fuller's earth. West of Cuthbert the strata appear to be of dark-red, argillaceous sand with a few clay laminæ, and fine gravel.

Thickness.—The exact thickness of the undifferentiated Claiborne deposits is not known. In the Fort Gaines area the thickness has been estimated as not exceeding 200 feet. The beds probably thin to the eastward.

DEPOSITS OF JACKSON AGE[1]

The deposits of Jackson age in Georgia include the Ocala limestone and the Barnwell formation, which are at least partly contemporaneous.

OCALA LIMESTONE

Areal distribution and thickness.—The Ocala limestone is in general exposed over the southern part of the Dougherty Plain and over a northeastward interrupted narrow strip of country as far as the Ocmulgee River south of Macon. Throughout this area probably its greatest thickness is around Albany, where the city well No. 2 indicates a thickness of about 300 feet.

[1]Cooke, C. W., and Shearer, H. K., U. S. Geol. Survey Prof. Paper No. 120-C, 1918.

Stratigraphic position and lithological nature.—The formation where exposed consists of sands, clays, and rather pure, white, fossiliferous limestones. The latter material has through solution formed innumerable lime sinks so characteristic of the area. Some of the beds of limestone are silicified in many localities, giving large boulders of residual chert. Farther eastward, under cover of younger formations, the Ocala is shown by well cuttings to consist mainly of white fossiliferous limestones.

BARNWELL FORMATION

Areal distribution and stratigraphic position.—The Barnwell formation outcrops over an area about 35 miles wide, extending from the Ocmulgee River eastward to the Savannah River. Throughout the western part of this area it rests unconformably on the Cretaceous, while in the region south of Augusta it lies with conformity upon the McBean formation.

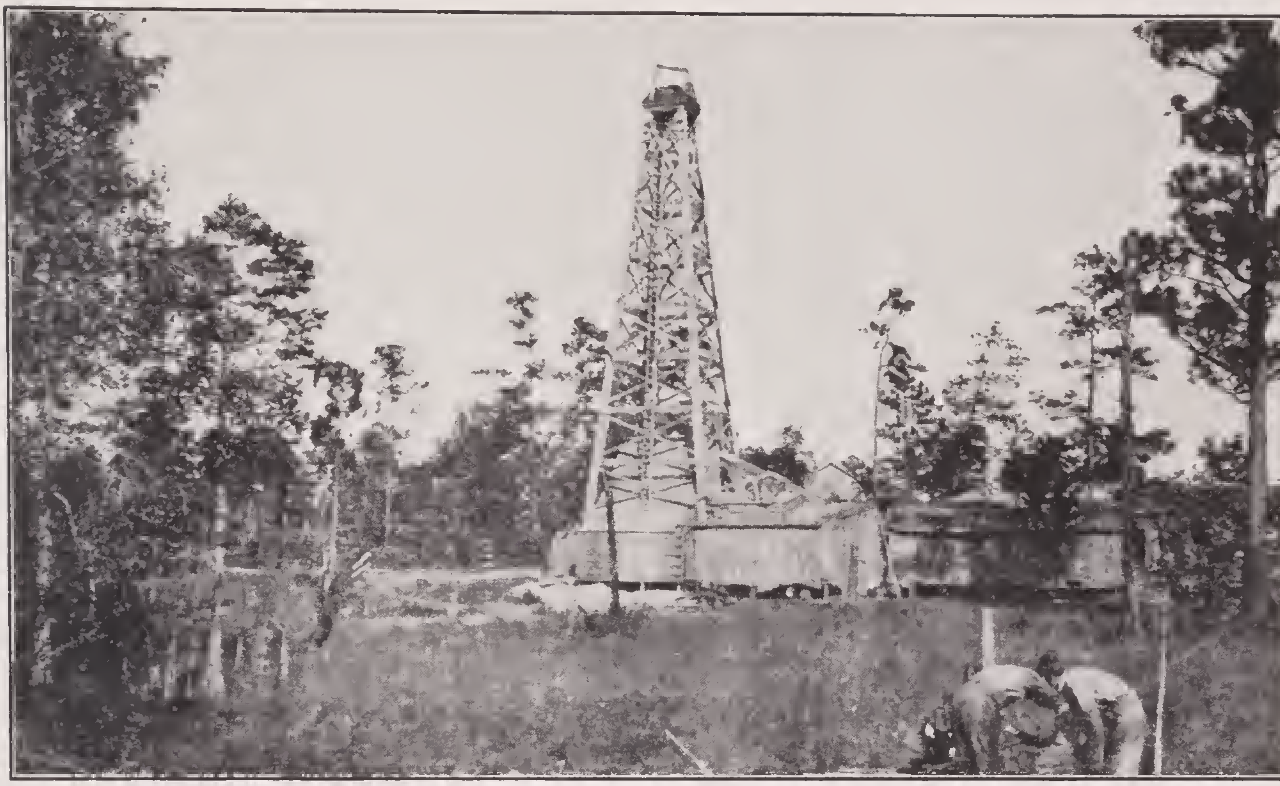
Lithologic nature and thickness.—In the Savannah River area the Barnwell consists chiefly of red sands with thin fossiliferous chert beds underlain by beds of impure fossiliferous limestone, marl, and clay. On passing westward the clay members become more prominent and include many commercial deposits of greenish gray fuller's earth. The maximum thickness of the exposed area of Barnwell is about 200 feet.

In the Ocmulgee River area the Barnwell formation interfingers with the Ocala limestone, the latter probably representing a deeper water phase of deposits of nearly the same age.

OLIGOCENE SERIES

VICKSBURG GROUP

There are no known exposures of deposits of Vicksburg age in Georgia older than the Glendon formation. In western Florida the Marianna limestone, of pre-Glendon Vicksburg age, is exposed a short



A. PROSPECT OIL WELL, MIDDLE GEORGIA OIL AND GAS COMPANY, NEAR JEFF DAVIS—COFFEE COUNTY LINE, 15 MILES WEST OF HAZELHURST—MARCH 1921.

B. INDURATED ALUM BLUFF FORMATION AT WATER FALLS ON MILL CREEK, JEFF DAVIS COUNTY.

distance west of the Chattahoochee River, and it is possible that deposits of this age are present in Georgia, over-lapped by the Glendon.

GLENDON FORMATION[1]

Areal distribution and thickness.—The Glendon outcrop forms a border inland from the Altamaha upland from the mouth of Flint River to Wrightsville, varying in width from about 8 to 40 miles. In addition an irregular strip, averaging about 15 miles in width, extends westward from Cordele to Fort Gaines. The Ocala area intervening between these two strips of Glendon outcrop was evidently at one time covered with Glendon material. The maximum thickness of the Glendon thoroughout its areal distribution is thought not to exceed 100 feet, averaging 50 feet. A small isolated area of Glendon outcrops in Screven and Burke counties in the Savannah River area.

Stratigraphic position and lithologic nature.—The Glendon formation unconformably overlies the Ocala limestone along the Flint River belt of outcrop from the mouth of the Flint to a point about 10 miles southeast of Oglethorpe. Thence it extends interruptedly, with an unconformable relation to the Ocala and Barnwell, respectively, eastward to Wrightsville. Near Oglethorpe it overlaps upon the Midway. Throughout the area extending westward from Cordele the upper edge of the belt lies unconformably on the Claiborne, while its southern edge rests unconformably on the Ocala. The exposed Glendon consists chiefly of chert-bearing sands, and clays. Under cover and at a few recently bared exposures the formation is chiefly limestone.

CHATTAHOOCHEE FORMATION[2]

Areal distribution and thickness.—In southwest Georgia the Chattahoochee formation is exposed over a few small isolated areas, including lime sinks, in Decatur, Grady, Thomas, Brooks, Lowndes, and

[1]Cooke, C. W., U. S. Geol. Survey Prof. Paper No. 132-A, 1923, and unpublished notes.

[2]Cooke, C. W., unpublished notes.

Echols counties. In the Savannah River region a small outcrop occurs along Brier Creek, in northeastern Screven County. The maximum thickness of the formation over the areas of exposure is probably about 100 feet.

Stratigraphy and lithologic Nature.—The Chattahoochee formation is generally regarded as Oligocene in age, although evidence now indicates that it may be early Miocene. It lies unconformably above the Glendon. This unconformity probably corresponds to the time interval represented in Alabama and Mississippi by the Byram marl, which is absent in Georgia. Throughout the western part of its area of outcrop the formation consists of sands, clays, and sandy, impure, conglomeratic limestone. Farther eastward in southern Georgia the limestone increases in purity but retains its conglomeratic nature.

MIOCENE SERIES

The Miocene strata outcrop over more than half of the Coastal Plain of Georgia, forming a belt 50 to 120 miles wide across the central portion of the Coastal Plain. The strike of the beds is approximately northeast. The areal extent is approximately outlined by the physiographic subdivisions of the Coastal Plain known as the Altamaha upland and the Southern lime-sink region. On the east the Miocene outcrops are bounded by the Okefenokee plain, and the inland or western limits are marked by the escarpment on the east side of the Flint River and north to Vienna, thence roughly northeast through Dublin, thence to Sandersville, then to Midville, and thence northeast to the Savannah River. (See maps I, III.)

The Miocene series embraces the Alum Bluff formation and the Marks Head and Duplin marls. The latter two formations are of insignificant areal extent as compared to the Alum Bluff formation.

ALUM BLUFF FORMATION

Distribution and character.—The Alum Bluff formation occupies practically the whole of the areal extent of the Miocene series, with the exception of small strips along Savannah, Altamaha, and Satilla rivers.

The formation varies considerably in lithologic character from place to place. It is often characterized by gray to red, indurated, coarse sands and gravels, often argillaceous, and commonly cemented by iron oxide. Usually associated with the sandstone are white to red, mottled, sandy, massive clays. These indurated sands and clays form steep bluffs along many of the streams, and also the cappings of many of the hills. Laterally the sands and clays vary rapidly, the more resistant portions being largely responsible for the topographic forms developed throughout the Alum Bluff area. Where the formation has been encountered in numerous wells, and at outcrops along some of the streams, the upper part consists of light-colored sands, clays, and gravel, and the lower part mainly of laminated, greenish to bluish marine clays, generally unfossiliferous, and often somewhat resembling fuller's earth. In places it contains thin flint beds, and at numerous localities thin beds of limestone are reported from the lower portion of the formation.

The formation is apparently all of shallow-water origin. It appears to be in large part marine, though some of the sands, clays, and gravels of the upper part seem to indicate, by their cross-bedding, their rapid lateral gradation, their oxidation, and their generally heterogeneous character, a fresh-water or stream origin.

Stratigraphic relationships.—The Alum Bluff, where buried, is separated from the overlying formations by an unconformity. In Johnson, Jefferson, Burke and part of Jenkins counties at least the Alum Bluff formation rests on Eocene strata from which it is separated by a major unconformity. In the southwestern corner of the

state the formation apparently rests conformably on the Chattahoochee formation. Along its inland limits, between Johnson County on the northeast and the southwestern corner of the state, the formation rests upon the Glendon formation, of Oligocene age, from which it is apparently separated by an unconformity, probably representing a considerable time interval, embracing all of Chattahoochee and possibly part of Glendon and Miocene time. In the northern part of Screven County the Alum Bluff rests upon beds of Tampa age, the exact relationship of the two not being clearly shown. The Tampa is considered to be approximately of Chattahoochee age, thus tending to show no time break of magnitude between the Tampa and the overlying Alum Bluff.

Thickness and rate of dip.—The thickness of the Alum Bluff formation varies from a thin covering along its inland limits to probably more than 350 feet along the present seacoast. In general the formation dips in a southeastward direction at the rate of from 3 to 5 feet per mile.

Structure.—Structurally the Alum Bluff formation has variable significance, which will be discussed in greater detail in succeeding pages of this bulletin. Suffice to say at this point that the upper indurated sands and clays, where exposed as outcrops, have no trustworthy significance from the point of indicating true structural conditions.

MARKS HEAD MARL[1].

Areal distribution and lithologic character.—The Marks Head marl has been differentiated along the Savannah River at and near Porter's Landing, Effingham County, in sections above Porter's Landing as far as Hudson's Ferry, and in sections below Porter's Landing as far as Sister's Ferry. The beds consist of gray to brownish, compact, argillaceous sands, with large calcareous nodules and some friable, phosphatic, fossiliferous sands. The maximum thickness observed is at Porter's Landing and totals about 45 feet.

[1]After Stephenson, L. W., and Veatch, Otto, U. S. G. S. Water-Sup. Paper No. 341, pp. 98-99, 1915.

Stratigraphic position.—The Marks Head marl rests upon the Alum Bluff formation, and from scanty evidence the two appear to be separated by an erosion unconformity. However, the paleontologic evidence especially tends to show that the time interval represented by the apparent unconformity is small. Lying above the Marks Head marl is the Duplin marl. These two formations are separated by an unconformity of considerable time magnitude, the Marks Head marl being early Miocene and the Duplin marl being late Miocene.

Structure.—Structurally the Marks Head marl has practically no significance, because of its very limited known extent. It dips gently to the south, at probably 4 feet or less to the mile.

DUPLIN MARL[1]

Areal distribution and lithologic character.—The Duplin marl has been differentiated on the Savannah River at Porter's Landing, Mt. Pleasant Landing, 1½ miles below Porter's Landing, in sections as far above Porter's Landing as Hudson's Ferry, and as far below Porter's Landing as Parisburg, S. C., 23 miles above Savannah. On the Altamaha River the formation has been differentiated at Doctortown, Buzzards Roost Bluff, and at Bugs Bluff.

The formation as exposed on the Savannah River is mainly a shell marl, made up of shells in a matrix of coarse phosphatic sand. In places, however, the formation is largely fine, gray to brown, quartz sand, with very few fossils and little calcareous material. On the Savannah River the maximum thickness is probably not more than 10 or 12 feet.

The Duplin marl as exposed on the Altamaha River consists of soft, sandy and pebbly shell marls, and compact, fine-grained, argillaceous, fossiliferous, bluish sands. It is probably not more than 12 or 15 feet in thickness.

---

[1]After Stephenson, L. W., and Veatch, Otto, U. S. Geol. Surey Water-Sup. Paper No. 341, pp. 99-100, 1915.

Stratigraphic position.—Along the Savannah River the Duplin marl rests unconformably on the Marks Head marl, or, where the latter is absent, upon the Alum Bluff formation. The formation is generally unconformably overlain by younger formations.

Along the Altamaha River the Duplin marl unconformably overlies the Alum Bluff, and in turn is overlain by loose sands of probably both Pliocene and Pleistocene age.

Structure.—Along both the Savannah and the Altamaha Rivers the Duplin marl is of too limited extent to be of value structurally. It probably dips south and southeast at the rate of about 3 feet per mile.

UNCLASSIFIED MIOCENE DEPOSITS

Along the Satilla River in the vicinity of Owens Ferry a compact sand and calcareous sandstone of Miocene age is exposed at low tide.

Material dredged from the Brunswick River at Brunswick is considered to be of Miocene age. It consists of fragments of bone, and teeth, quartz sand and pebbles, sandy marl or shells in a matrix of phosphatic sand, argillaceous limestone, and hard clay. The extent of the deposits is not known.

PLIOCENE (?) SERIES[1]

CHARLTON FORMATION

The Pliocene series is probably represented in the Coastal Plain of Georgia by the Charlton formation. Its areal extent is quite small, being confined to a narrow strip along the St. Mary's River from Stokes Ferry, 11 miles south of St. George, Charlton County, to Orange Bluff, near King's Ferry, Florida. Fossiliferous marls referable to the same formation have been found at Burnt Fort, on the Satilla River, 12 miles northeast of Folkston, and 6 miles east of Winoker, both in Charlton County, and at the King plantation, 6 miles south of Atkinson, Wayne County.

The formation consists of an argillaceous limestone and clay material. The exact thickness of the formation is not known, as no ex-

[1]After Stephenson, L. W., and Veatch, Otto, U. S. Geol. Survey Water-Sup. Pap. No. 341, pp. 100-102, 1915.

posures of more than 15 feet of strata have been observed. Structurally the formation has little or no significance.

QUATERNARY SYSTEM

PLEISTOCENE SERIES[1]

COLUMBIA GROUP

The Pleistocene deposits of the Coastal Plain of Georgia consist of thin accumulations of sand, clay, and gravel deposited on marine and river terraces. These deposits are not superimposed one upon the other but occupy terraces at different topographic levels, thus tending to merge laterally. The details of the Pleistocene deposits have not yet been fully worked out, and will probably only finally be determined on detailed topographic work. The description as here given is taken from U. S. G. S. Water-Supply Paper 341, with only some of the major features set forth. The classification of the Pleistocene series thus given is as follows:

COLUMBIA GROUP:

Satilla formation:	Okefenokee formation:
Marine terrace deposits	Coastal terrace sand
Fluviatile deposits	Fluviatile deposits

OKEFENOKEE FORMATION

Distribution and character.—The Okefenokee formation is made up in part of coastal terrace deposits and in part of deposits laid down on fluviatile or river terraces. During the deposition of the Okefenokee formation the coast line was probably 40 to 75 miles inland from its present position. The coastal terrace deposits and the river terrace deposits were probably laid down at the same time.

Coastal deposits.—The coastal terrace portion of the Okefenokee formation corresponds essentially to the physiographic subdivision of the Coastal Plain designated the Okefenokee Plain. (Map p. 60.) The western boundary is marked approximately by a line from Sister's

[1]After Stephenson, L. W., and Veatch, Otto, U. S. Geol. Survey Water-Sup. Pap. No. 341, pp. 102-111, 1915.

Ferry or Clyo, on the Savannah River, southwestward through the town of Flemington to Jesup, thence to Waycross and thence along the western boundary of Okefenokee Swamp. The eastern boundary is marked by a rather distinct escarpment 20 to 40 miles from the present coast, which separates the plain from the Satilla terrace. (Map page 60.)

In general the deposits of the Okefenokee formation consists of gray quartz sand. Some red and yellow sands, with occasional thin clay beds, probably belong to the same formation. The sand is usually loose, or entirely unconsolidated, but becomes more compact with depth. In places the sand is indurated, probably by a cementing material of iron oxide.

The thickness of the sand is nowhere very great, probably never exceeding 20 feet, and averages less than 10 feet. It is spread over a practically featureless flat plain, with occasional bluffs 30 or 40 feet high along a few of the larger streams. In places the sands have been piled up as low ridges and hills.

Structurally the Okefenokee formation is of very little significance, conforming to the gentle seaward slope of the plain and varying in elevation from about 60 to 125 feet.

Fluviatile terrace deposits.—Bordering the major streams of the Coastal Plain are the remnants of a plain higher than the Satilla plain and somewhat lower than the general upland portions of the region. The deposits on this plain are believed to be contemporaneous with the coastal deposits of the Okefenokee formation. The river terraces and the coastal terraces tend to merge one with the other.

The river-terrace plains are 50 to 125 feet above the present rivers. The deposits overlie successively the older formations of the Coastal Plain, from the Cretaceous to the Pliocene. Often times, due to lithologic similarity, it is difficult to separate the terrace deposits from the underlying older formations.

The deposits consist in the main of red argillaceous sands, with pebbles and coarse gravels in places. The sands are chiefly of quartz

and most of the pebbles are quartz or quartzite, but a few are limestone, chert, or limonite.

The formation is nowhere of any great thickness, being usually less than 20 feet and rarely exceeding 50 feet. It is usually poorly consolidated, but in places is cemented with iron oxide. The deposits are confined to the plains bordering the rivers, and range from 1 to 10 miles in width.

Like the deposits of the coastal terrace, those of the stream terraces are lacking in any structural significance.

SATILLA FORMATION

The Satilla formation occupies a strip 20 to 30 miles wide bordering the present coast line. It occupies the physiographic subdivision of the Coastal Plain designated the Satilla coastal lowland. (Map p. 60.) Two types of deposits are embraced within the formation, namely the coastal marine deposits and the river terrace or fluviatile deposits.

Coastal terrace deposits.—The coastal terrace deposits rest upon an old wave-cut terrace extending 20 to 30 miles inland from the present coast. They consist of greenish to bluish marine clays, gray, white and yellow sands, and some thin layers of gravel.

The sands are of the greatest extent, and consist largely of quartz grains, with small amounts of mica, magnetite, ilmenite, and some other rare minerals. They are nowhere consolidated. The clays are fine textured and generally massive in character. In places they become calcareous and contain some fossil remains. The sands and clays are closely associated and are regarded as contemporaneous. The maximum thickness of the deposits probably does not exceed 50 feet.

Fluviatile terrace deposits.—The fluviatile deposits of the Satilla formation form low terraces along the major streams of the Coastal Plain. They consist of unconsolidated sands, clays, and gravels. These vary somewhat in character along the different streams.

The river terraces of the Satilla formation are relatively flat plains lying 10 to 50 feet above the rivers and varying in width from a few yards up to 10 miles. In general they extend from the Fall line to the marine terrace plain with which they merge.

Structurally the marine terrace deposits and the river terrace deposits of the Satilla formation have no real significance, being without distinct continuous beds and forming a thin mantle over older formations.

REGIONAL DIP OF FORMATIONS

The regional dip of the formations of the Coastal Plain of Georgia is approximately southeast. The rate of dip is about as follows: Crystalline floor, 35 feet per mile; top of upper Cretaceous, 20 feet per mile; top of Eocene, 8 feet per mile; top of Oligocene, 5 feet per mile; top of Miocene, 3 feet per mile.

CORRELATION TABLE OF PRINCIPAL GULF COAST FORMATIONS, SHOWING THOSE THAT HAVE PRODUCED OIL OR GAS

The following table shows the principal formations of the Gulf Coast region from Georgia to Texas, inclusive. Stars indicate the formations which are known to have produced oil or gas. It will be seen that throughout the Coastal Plain of Georgia are many formations the approximate equivalents of which farther west are productive. This, however, does not necessarily indicate that the corresponding formations will be found productive in Georgia.

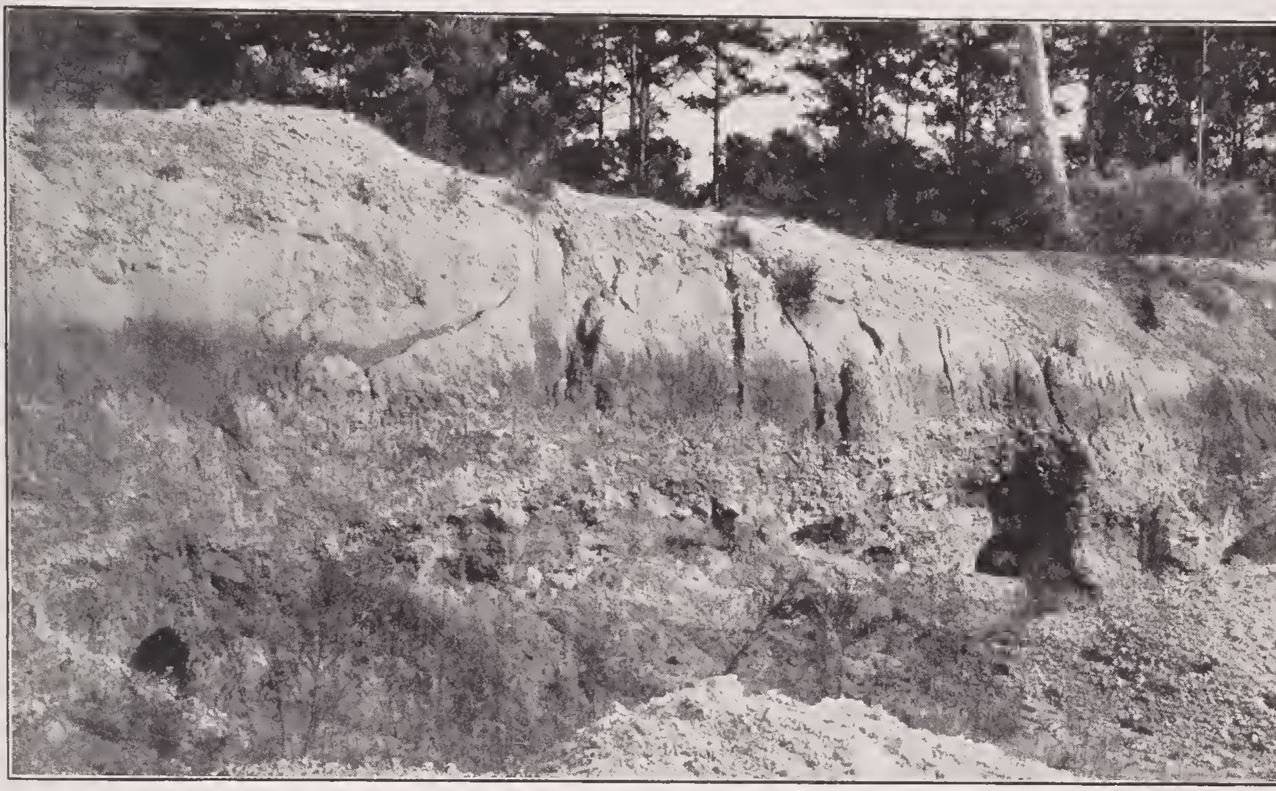
Correlation Table of Principal Gulf Coast Formations, Showing Those That Have Produced Oil or Gas.

Age	Central and Western Texas	East Texas	Louisiana	Mississippi	Alabama	Georgia	Florida
Pleistocene	Terraces Beaumont Lissie	Terraces Beaumont Lissie	Terraces Port Hudson Lissie*	Terraces Port Hudson Natchez	Terraces	Terraces Columbia: Satilla and Okefenokee	Terraces Palm Beach Miami Key West Key Largo Lostmans River Fort Thompson beds of Sellards.
Pliocene (?)	Reynosa	Reynosa				Charlton	Charlton
Pliocene	Lagarto Lapara	Fleming clay* | DeWitt form.	Citronelle	Citronelle	Citronelle		Citronelle Bone Valley and Alachua | Caloosahatchee and Nashua
Miocene	Oakville		Pascagoula* Hattiesburg	Pascagoula Hattiesburg	Pascagoula Hattiesburg	Duplin Marks Head Alum Bluff	Choctawhatchee | Jacksonville Alum Bluff
Oligocene	Catahoula	Catahoula*	Catahoula Vicksburg	Catahoula Vicksburg: † Byram Glendon Marianna Forest Hill | Red Bluff	Catahoula Vicksburg: Byram Glendon Marianna	Chattahoochee Glendon. Marianna (?)	Chattahoochee | Tampa | Catahoula Vicksburg: Byram Glendon Marianna
Eocene	Frio Fayette* Jackson	Jackson*	Jackson	Jackson	Jackson	Barnwell / Ocala	Ocala
	Claiborne: Yegua* Cook Mtn.* Mt. Selman*?	Claiborne: Yegua* Cook Mtn.* Mt. Selman*	Claiborne: Yegua St. Maurice	Claiborne: Yegua Lisbon Tallahatta Winona	Claiborne Gosport Lisbon Tallahatta Winona	Claiborne / McBean	Not exposed
	Wilcox	Wilcox ‡	Wilcox	Wilcox	Wilcox	Wilcox	Not exposed
	Midway*	Midway ‡	Midway	Midway	Midway	Midway	Not exposed

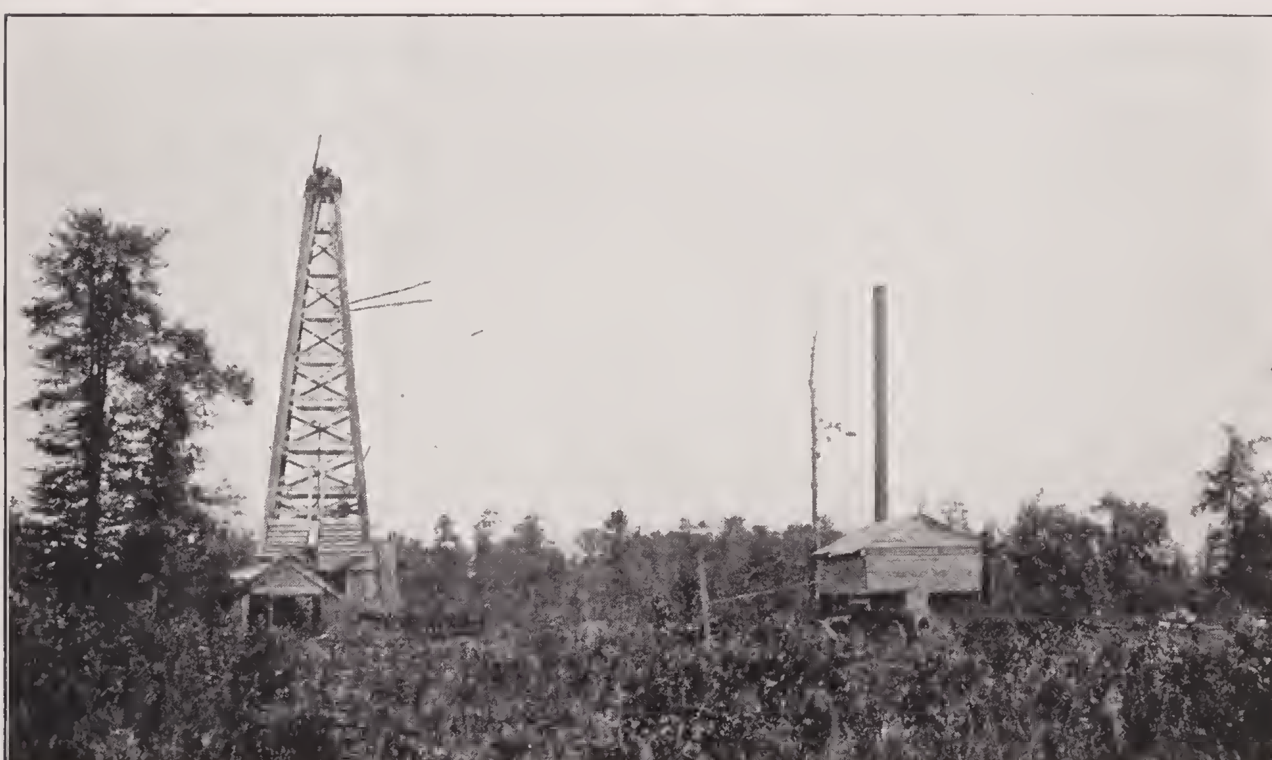
Correlation Table of Principal Gulf Coast Formations, Showing Those That Have Produced Oil or Gas.—(Continued.)

Age	Central and Western Texas	East Texas	Louisiana	Mississippi	Alabama	Georgia	Florida
Upper Cretaceous	Navarro* Taylor* Austin* Eagle Ford Woodbine*	Arkadelphia Nacatoch* Marlbrook Austin (Annona)* Brownstown Blossom* Eagle Ford Woodbine*	Arkadelphia Nacatoch* Marlbrook Austin (Annona)* Brownstown Blossom* Eagle Ford* Woodbine*	Ripley Selma Eutaw Tuscaloosa	Ripley Selma Eutaw Tuscaloosa	Ripley Eutaw	Not exposed
Lower Cretaceous	Thick deposits variously subdivided. Some oil.	Not exposed. Some gas in deep wells.	Not exposed. Oil in deep wells.			Lower Cretaceous (?)	Not exposed.

*Formations known to have produced oil or gas are indicated by a star. The nomenclature, correlations, and known oil and gas-producing formations have been brought up to date by the United States Geological Survey.
†Show of gas.
‡Showing of oil.



A. EOCENE BASAL CONGLOMERATE OVER BAUXITE, EAST FACE OF CARSWELL MINE, NEAR McINTYRE, WILKINSON COUNTY.



B. PROSPECT OIL WELL, SAVANNAH OIL AND GAS CORPORATION, 7 MILES WEST OF SAVANNAH—JULY, 1920.

SOME DEEP WELLS OF THE COASTAL PLAIN

The general lithologic nature of the formations of the Coastal Plain, as far down in the geologic column as near the top of the Eutaw formation, is indicated by the following well logs. These logs are either compiled from examinations of cuttings or are taken from United States Geological Survey Water-Supply Paper No. 341 or from bulletins of the Georgia Survey.

WELL LOGS

Log of city artesian well No. 2, Albany, Ga.

		Depth, feet
Tertiary:		
35.	Red clay	0–20
34.	Light-colored clay	20–23
33.	Coarse sand (Vicksburg)	23–25
32.	Light-colored clay and coarse quartz sand	25–35
31.	Limestone; *Orbitoides sp.* at 150 feet and from 190 to 200 feet	35–200
30.	Gray limestone; *Orbitoides sp.*, echinoid, bryozoa, *Terebratulina lachryma* (Morton); some shale from 230 to 240 feet	200–280
29.	Gray sand with comminuted shells (*Ostrea*)	280–285
28.	Some shale, coarse sand, shell, and sharks teeth at	311
27.	Hard layer; *Ostrea divaricata* Lea	318–320
26.	*Ostrea divaricata* Lea at	330
25.	*Ostrea alabamensis* Lea at	340
24.	Shale or marl, water vein at	350
23.	*Ostrea divaricata* Lea and *Ostrea alabamensis* Lea at	363
22.	Bed of lignite at	367
21.	Bed of lignite at	400
20.	Sand	400–475
19.	Stiff, blue clay; echinoid spines, *Lamna sp.* (teeth)	470–475
18.	Stiff blue clay	475–480
17.	Hard gray sandstone	485–488
Upper Cretaceous:		
Ripley formation:		
16.	*Ostrea sp.* and *Exogyra costata* Say?	500–510
15.	Pyrite and small oysters at	520
14.	Greensands and greenish micaceous shales	530–540
13.	Gray sand with black particles at	600
12.	Water-bearing horizon, limestone, with pieces of hard gray sandstone, between 785 and 790 feet	690–790
11.	Hard rock	790–800
10.	Clay shales; white limestone between 835 and 840	800–850
9.	Limestone, shales, etc. At 880 feet limestone or calcareous sand, also light-gray micaceous sand	850–890
8.	Grayish sand, calcareous, fragments, hard black pieces of pebbles; *Ostrea sp.*, *Anomia argentaria* Morton. *Gryphæa vesicularis* Lamarck (young) at 890 feet. Water-bearing micaceous stone between 920 and 930 feet	890–940
7.	Blue, micaceous clay at 950 feet, thick-shelled oyster, *Gryphæa sp.;* the same also at 1080 feet; at 1100 feet gray sand with *Ostrea subspatulata* Forbes, *Exogyra costata* Say	940–1100

Log of city artesian well No. 2, Albany, Ga.—continued.

6.	Stiff blue clay, micaceous sandstone; *Ostrea cretacea* Morton(?)	1100–1200
5.	Very stiff blue clay, at 1255 feet, streaks of sand and shells, a small flow of water; from 1240 to 1260, soft shiny blue clay	1200–1260
4.	Marl, gray sand, sandstone lumps	1260–1270
3.	Gray and black sand, sandstone lumps	1270–1310
2.	Black, irregular, water-worn pebbles with hard crystalline fracture; coarse and fine quartz sand, shells, decayed wood; third water-bearing stratum; 50 gallons per minute	1310–1315
1.	Well ends in quartz sand at	1320

Fossils from this well, identified by Dr. T. W. Vaughan, indicate Tertiary material down to 500 feet, with the Ripley formation, of Upper Cretaceous age, from 500 feet to the bottom. The Tertiary formations penetrated apparently include, in descending order, the Ocala, Claiborne, Wilcox and Midway formations.

Log of oil prospect well at Cherokee Hill, 6 miles northwest of Savannah

	Depth, feet
Dark-gray sand with carbonaceous material	21
Medium-grained gray sand with fragments of shell	240
Porous, gray, fossiliferous limestone; bryozoa abundant	250
Same as 250	260
Same as above, with some flint	270
Same as 250, sea urchin fragments	280
Same as above, with some flint	300
Same as above, though darker color	350
Light gray, consisting almost entirely of bryozoa fragments	360
Same as above	370
Same as above	380
Same as above	390
Same as above	400
Same as above	410
Same as above, but whiter	425
Same as above, but whiter	430
Same as above, but whiter	440
Same as above, but whiter	450
Same as above, but whiter	460
Soft, porous, fossiliferous limestone	465
Same as 360	470
Same as 465	475
Same as 470	485
Largely bryozoa remains	500
Dark-gray limestone; nummulites and bryozoa	510
Same as above	520
Same as above	530
Same as above	540
Same as above	550
Porous, gray limestone; nummulites abundant	560
Same as above	570
Same as above	580
Same as above	590
Same as above	600

Log of oil prospect well at Cherokee Hill, 6 miles northwest of Savannah—con.

	Depth, feet
Porous limestone; nummulites not so numerous	610
Mostly calcareous sand; but few fossils	620
Same as above	630
Same as above	640
Same as above	650
Same as above	660
Same as above; more fossils	670
Same as above; particles of limestone larger	680
Gray fossiliferous limestone	690
Gray fossiliferous limestone	700
Gray fossiliferous limestone	710
Gray fossiliferous limestone	720
Gray fossiliferous limestone	730
Gray fossiliferous limestone	740
Gray fossiliferous limestone	750
White, fairly hard limestone; crinoid fragments	760
Same as last	770
White, granular limestone; bryozoa, gastropods	810
Yellowish white, fairly hard limestone; numerous pectens, bryozoa, and other fragments	820
Same as last, not so yellow	830
Same as last	840
Gray, rather hard limestone, with considerable dark-gray flint; bryozoa and lamellibranchs in the limestone	850
White, hard limestone, fossiliferous	860
White, fairly hard limestone, with numerous fragments of large shells and pieces of bryozoa and crinoids, practically no flint	870
Mostly light to dark-gray flint; gray flint is somewhat sandy; a little limestone with usual fossils	880
Light and dark-gray, flint-like cast, some pieces altering to gray sandy material; pyrite fragments	890
Same as last	900
Same as last, with more of the light-gray sandy material	910
Like last, with about half of it of limestone; considerable fine-grained sandstone	920
Fine-grained, gray, sandy flint and dark-gray flint, a little limestone	940
Same as last	950
Light-gray, very soft, marly limestone; no fossils preserved; pieces of phosphate, glauconite, and possibly fragments of shark teeth	960
Same as last, more glauconite and phosphate	970
Same as last	980
Pale-green marl with considerable limestone; fragments of bryozoa, crinoids, some pyrite, and a little flint (probably dropped from above)	990
Gray to green marl with some limestone containing bryozoa, lamellibranchs, and other fossil fragments; green marl has large amount of glauconite and possibly some organic matter	1000
Pale grayish-green marl, with no fossils imprints. Some glauconite	1010
Same as last	1030
Same as last, darker in color	1040
Same as last	1050
Same as last	1060
Same as last	1080
Same as last	1090
Same as last	1100
Same as last	1110
Same as last	1130
Same as last	1140
Same as last	1150
Same as last	1160
Same as last	1170
Same as last	1180

Log of oil prospect well at Cherokee Hill, 6 miles northwest of Savannah—con.

	Depth, feet
Dark-gray to blue flint with some sandy flint and a little marl; no fossil traces	1190
Same as last	1200
Same as last, with some white sandy marl	1210
Same as last. The flint in this and similar samples is probably in form of nodules irregularly distributed through a gray sandy marl, as fragments appear showing a gradation from the dark flint into the sandy marl	1220
Same as last	1230
About half is dark flint and the rest a gray sandy marl	1240
Same as 1260	1250
Sand, flint, and a little lime and marl; fossil fragments in lime (in small pieces)	1260
Same as last	1270
Mostly dark-gray flint	1280
Dark-gray flint with some sandy marl	1290
Dark-gray flint	1300
Soft, gray to bluish, limy marl; no fossil traces retained in sample	1310
Same as 1310	1320
Same as last	1330
Same as 1330	1340
Same as last	1350
Dark-green, soft marl, sandy; appears to be mostly glauconite	1360
Same as last, a little flint	1370
Same as last	1380
Gray, arenaceous, glauconitic marl; sand fine, mainly quartz; echinoderm spines, ostracods, and elongated and coiled types of Crystellaria. Heat gives bituminous odor and slight trace of colorless oil	1390
Gray marl similar to 1390. Nodosaria	1400
Gray marl like 1400	1410
Gray marl like 1400	1420
Gray marl like 1400, except lighter in color and smaller trace of condensed oil	1430
Gray marl like 1400, except lighter in color, less glauconite, no Crystellaria	1440
Gray marl similar to 1440. No ostracods. Heat gives bituminous odor but no condensation of oil	1450
Greenish gray, pulverulent, glauconitic marl, with about 35% glauconite; grains of limestone and quartz	1460
Light-gray, pulverulent, glauconitic marl similar to 1460, except only about 12% glauconite	1470
Light-gray, pulverulent, arenaceous marl; about 50% fine quartz sand; limestone and some glauconite. Fossils not abundant. Heat gives faint bituminous odor	1480
Similar to 1480	1490
Similar to 1480, with more glauconite	1500
Light-gray marl; grains of quartz, glauconite, and limestone; some shell fragments. Echinoderm spines and Nodosaria abundant. Heat gives faint bituminous odor	1510
Similar to 1510	1520
Similar to 1510	1530
Gray marl, very little sand; Nodosaria and echinoderm spines. Heat gives bituminous odor and trace of colorless oil	1540
Similar to 1540	1550
Similar to 1540	1560
Similar to 1560	1570
Similar to 1560	1580
Similar to 1560	1590
Similar to 1560	1600
Similar to 1560	1610
Gray argillaceous marl. No fossils. Heat gives bituminous odor and trace of condensation of colorless oil	1630
Similar to 1630	1650
Similar to 1630. Echinoderm spines	1660
Similar to 1660	1670
Similar to 1660	1680

Log of oil prospect well at Cherokee Hill, 6 miles northwest of Savannah—con.

	Depth, feet
Similar to 1660. Small pyrite cubes abundant	1690
Gray marl containing pyrites. Very few fossils. Heat gives bituminous odor and trace of colorless oil	1700
Similar to 1700	1710
Similar to 1700	1720
Similar to 1700	1730
Similar to 1700	1740
Similar to 1700	1760
Similar to 1700	1780
Similar to 1700	1800
Similar to 1700	1820
Similar to 1700	1840
Similar to 1700	1860
Similar to 1700	1880
Similar to 1700	1900
Similar to 1700	1920
Similar to 1700; *Belemnitella americana*, Ripley	1940
Similar to 1700. Heat gives faint bituminous odor but no condensation of oil	1950
Similar to 1950	1970
Similar to 1950	1980
Light-gray sandstone, fine quartz grains cemented firmly by calcium carbonate. No fossils	2000
Unconsolidated white sand, similar to 2000 except no cementation. No fossils	2010
Unconsolidated gray sand, mixture of fine quartz sand and fine limestone particles. No fossils	2020
Similar to 2020	2035
Gray marl. No fossils. Heat gives bituminous odor and trace of colorless oil	2040
Similar to 2040, except only slight trace of oil	2050
Similar to 2050	2060
Similar to 2040, except no condensation of oil	2070
Similar to 2070	2090
Similar to 2040	2100
Similar to 2040	2130

The first 250 feet of strata penetrated doubtless include Pleistocene sands and clays, the Duplin and Marks Head marls, and the Alum Bluff formation. That portion of the column from 250 to about 1000 is thought to represent, in part at least, the Glendon formation and the Ocala limestone. A greater part of the column below 1350 is apparently of Upper Cretaceous age, with definite Ripley shown by *Belemnitella americana* at 1940. The well apparently stops in the Ripley formation. Casing was set at 27, 107, 250, 1426, 1630, and 2126 feet. A little gas was reported at 1000 feet and showing of oil at 1590, with salt water at 2000.

Log of oil prospect well at Scotland, Telfair County

	Depth, feet
Quartz sand and small gravel cemented by yellowish red clay	0–10
Quartz sand and gravel	10–20
Mixture of sand and very dark brownish-gray clay with small fragments of lignite	20–30

Log of oil prospect well at Scotland, Telfair County—continued.

	Depth, feet
Quartz sand and fine gravel cemented by yellowish clay	23–25
Fine, gray, quartz sand with some rounded fragments of light-colored clay	25–55
Similar to above	55–77
Similar to above except sand is cemented by drab-colored clay	75–80
Very fine quartz sand cemented by pale-yellow clay	80–100
Similar to 25-55 feet	100–138
Soft, white, chalky limestone locally grading into marl	138–140
Fine guartz sand with few black grains and some shell fragments	138–180
Gray, porus limestone with shell fragments	180–185
Fine, calcareous, quartz sand and shell fragments	185–190
Pale-yellow, soft, powdered, porous, fossiliferous limestone	190–350
Fragments of limestone, flint, and fossils, including orbitoids	350–400
Pale-yellow, soft, porous limestone with orbitoids	400–415
Yellow, soft, porous limestone consisting largely of small bryozoa	415–435
Small yellowisb fragments of limestone and shells. Orbitoids and bryozoa abundant	435-440
Similar to above but larger fragments	440–445
Soft yellow limestone	440–450

This well begins in the Alum Bluff formation, which extends to about 180 feet. The greater part of the limestone from 180 feet to the bottom is of Glendon age, but the upper part may be Chattahoochee.

Log of oil prospect well at Fredel, 10 miles south of Waycross

	Depth, feet
Gray quartz sand with fragments of white limestone and clay	100
Similar to above, with quartz pebbles	160
Similar to 100	185
Similar to 160	225
Similar to 160	261–290
Black, phosphatic, hard sandstone	290–299
Mixture of coarse quartz sand pebbles and arenaceous, hard, white limestone fragments	299–320
Hard, white, dense limestone	325
Hard, white, fossiliferous, arenaceous limestone, with abundance of shells, partly as casts	435
Similar to above	450
Dense, hard, yellowisb-brown, crystalline limestone, with Crystellaria and echinoderm spines	800
Similar to above	820
Wbite limestone with abundance of Orbitoides-like forms and bryozoa, shell fragments and Crystellaria	840
Dense brownisb-yellow limestone with small orbitoidal forms and Crystellaria	860
Dense, yellowish-brown limestone	932–950
Ligbt-yellow limestone with orbitoidal forms, Crystellaria, and echinoderm spines	1120
Dense brownish-yellow limestone with coiled foraminifera resembling Crystellaria	1153
Similar to 1120	1314–1337
Similar to 1120, with abundance of orbitoidal forms and Crystellaria	1330–1340
Similar to above except no orbitoids	1351–1357
Similar to 1120, with bryozoa	1357–1363
Similar to above	1363–1369
Similar to above	1369–1382
Gray limestone with orbitoids, bryozoa, Crystellaria, and flint and sbell fragments	1382–1390

Log of oil prospect well at Fredel, 10 miles south of Waycross—continued.

	Depth, feet
Soft white limestone with bryozoa, Crystellaria, orbitoids, and echinoderm spines	1390–1396
Same as above	1396–1401
Same as above	1401–1408
Same as above	1408-1423
Pale-yellow limestone with bryozoa, echinoderm spines, Crystellaria, and shell fragments	1423-1430
Same as above	1440–1452
Soft white limestone with abundance of foraminifera, including orbitoids and Crystellaria, echinoderm spines	1452–1460
Same as above	1467–1475
Same as above, with bryozoa	1475–1482
Same as above, with bryozoa	1482–1487
Same as above, without bryozoa	1487–1495
Same as above, without bryozoa	1495–1501
Yellow limestone with indistinct foraminifera	1501–1512
Soft white limestone with orbitoids, Crystellaria, and similar coiled forms	1512–1521
Similar to above	1521–1538
Similar to above	1546–1552
Similar to above	1552–1565
Similar to above	1565–1582
Similar to above	1582–1595
Similar to above	1595–1600
Similar to above	1600–1607
Similar to above	1607–1613
Similar to above	1613–1616
Similar to above	1624–1630
Similar to above	1630–1635
Similar to above	1635–1641
Similar to above	1641–1656
Similar to above	1656–1660
Similar to above, except no orbitoids	1660–1665
Soft, white, chalky limestone with some indistinct organic forms	1665–1672
Similar to above, with numerous Crystellaria-like forms	1672–1680
Soft, white limestone with foraminifera, including Crystellaria and echinoderm spines	1680–1691
Similar to above	1691–1700
Similar to above	1700–1706
Similar to above with shell fragments	1706–1711
Similar to above	1711–1718
Similar to above with orbitoids	1718–1725
Similar to above with orbitoids	1725–1730
Similar to above with orbitoids in abundance	1730–1735
Similar to above with orbitoids in abundance	1735–1748
Similar to above with orbitoids in abundance	1748–1760
Similar to above with orbitoids in abundance	1760–1773
Similar to above with orbitoids in abundance	1773–1782
Similar to above with orbitoids in abundance	1782–1790
Similar to above with orbitoids in abundance	1790–1800
Similar to above with shell fragments and bryozoa	1800–1810
Similar to above	1810–1818
Similar to above with glauconite	1818–1825
Similar to above with glauconite and flint	1840–1845
Soft white limestone with flint, shell fragments, and indistinct organic forms	1846–1852
Soft chalky limestone with flint, orbitoids, Crystellaria, and echinoderm spines	1852–1859
Similar to above	1859–1865
Similar to above	1865–1869
Similar to above with more flint	1869–1873
Similar to above	1873–1876
Similar to above	1880–1886

Log of oil prospect well at Fredel, 10 miles south of Waycross—continued.

	Depth, feet
Gray, slightly argillaceous limestone with organisms above, and some flint	1886–1891
Similar to above with very little flint	1891–1900
Similar to above with very little flint	1900–1906
Similar to above with very little flint	1906–1912
Similar to above with very little flint	1912–1919
Similar to above with yellow, flinty	1919–1925
Similar to above	1925–1931
Similar to above	1931–1938
Pale-yellow and gray limestone with orbitoids, Crystellaria, and echinoderm spines	1938–1944
Similar to above except lighter in color	1944–1950
Similar to above except lighter in color	1955–1961
Similar to above except few orbitoids only	1961–1965
Similar to above except few orbitoids only	1965-1971
Similar, except abundance of echinoderm stems and bryozoa	1971-1979
Similar to above	1979–1985
Pale-yellow limestone with abundance of foraminifera, including Crystellaria, bryozoa, and echinoderm spines	1985–1990
Same as above	1995–2000
Pale-yellow limestone with Crystellaria, bryozoa, orbitoids, Nodosaria, and other coiled foraminifera	2000–2009
Similar, except no Nodosaria	2009–2017
Similar, except no Nodosaria	2017–2026
Similar, except no Nodosaria	2026–2040
Similar, with Nodosaria	2040–2046
Similar, with Nodosaria	2046–2058
Similar, with Nodosaria and sponge spicules	2055–2063
Similar, with Nodosaria and abundant bryozoa	2063–2076
Similar, with Nodosaria and abundant bryozoa	2071–2081
Similar, with Nodosaria and abundant bryozoa	2081–2091
Similar, with Nodosaria and abundant bryozoa	2091–2098
Similar, with Nodosaria and abundant bryozoa	2098–2107
Similar, with Nodosaria and abundant bryozoa	2107–2115
Similar, with Nodosaria and abundant bryozoa	2115–2122
Similar, with Nodosaria and abundant bryozoa	2122–2130
Yellow limestone with abundance of echinoderm spines and Nodosaria	2130–2134
Gray soft limestone, with orbitoids, bryozoa, and echinoderm spines in abundance; some clay present	2135–2140
Similar, with some glauconite, Nodosaria, and white limestone fragments	2140–2145
Gray limestone with glauconite, bryozoa, echinoderm spines, and Nodosaria	2145–2153
Gray marl with glauconite, Nodosaria, Crystellaria, and other organic forms	2153–2160
Gray calcareous sand with shell fragments, shark's teeth, and glauconite. Heat test gives distinct odor of oil but no condensation	2287–2290
Similar to above	2290–2295
Fine, gray, calcareous, quartz sand with shark's teeth, shell fragments, glauconite, echinoderm spines, and Nodosaria	2377–2379
Gray, fine-grained, calcareous quartz sand	2450–2462
Similar to above with shell fragments	2471–2490
Similar to above with shell fragments	2496–2510
Gray, slightly calcareous, quartz sand with limonitic stains, probably from bit fragments	2505–2550
Similar to above with echinoderm spines	2550–2560
Similar to above with echinoderm spines	2660–2674
Similar to above with glauconite and Crystellaria-like forms. Somewhat less sand than above. Contains traces of oil	2705–2714
Similar to above	2714–2723
Fine, gray, calcareous quartz sand with echinoderm spines, ostracods, and Crystellaria. Contains traces of oil	2830–2834
Similar to above with Nodosaria. Traces of oil	2834–2870

Log of oil prospect well at Fredel, 10 miles south of Waycross—continued.

	Depth, feet
Fine, gray, calcareous, quartz sand with Nodosaria, echinoderm spines, and glauconite. Traces of oil	2870–2900
Similar to above. Traces of oil	2900–2910
Similar to above. Very slight trace of oil	2916–2940
Very fine-grained argillaceous quartz sand with glauconite; some coiled and some pear-shaped fossil forms. Slight trace of oil	2940–2952
Similar to above. Traces of oil	2952–2998
Similar to above. Very slight traces of oil	3000
Dark-gray marl with very little fine-grained quartz sand; pyrite crystals and echinoderm spines. Slight trace of bituminous matter but no free oil	3022

That part of the column from the surface down to 435 feet seems to include the Miocene and later formations. The material at 435 is of Chattahoochee age. From 800 to 2100 the beds probably represent the Glendon and the Ocala, but thickness seems excessive for these formations. There is nothing to show that the Cretaceous is reached, thus indicating an excessive thickness of Eocene and Oligocene. It is difficult to understand the apparent thickness of formations encountered in this well. Casing was set at 332, 436, 1306, and 2176 feet. A showing of oil and gas was reported at 1060 and salt water from 2000 to the bottom.

Log of oil prospect well near Doctortown, Wayne County

	Thickness, feet	Depth, feet
Sand	20	20
Sand and yellow clay with some shells	35	55
Sand and laminated clay	25	80
Conglomerate and marl. Water rises to within 20 feet of the surface	15	95
Sand, gravel, and laminated clay	40	135
Greenish-gray marl and chalky limestone with some pebbles	50	185
Quicksand and marl	45	230
Layers of hard rock, marl, and conglomerate	25	255
Marl with sandstone layers and some limestone	40	295
Quicksand with layers of conglomerate	30	325
Soft limestone and sandstone with flint layers 2 feet thick	28	353
Quicksand	40	393
Marl and soft limestone	15	408
Quicksand containing a large supply of water	7	415
Quicksand	50	465
Soft limestone	2	467
Hard limestone with layers of sand	44	511
Water-bearing limestone; quicksand at 793 feet	318	829
Gray limestone and brown sandstone	20	849
Sandstone	45	894
Limestone	35	929
Soft limestone	10	939

Log of oil prospect well near Doctortown, Wayne County—continued.

	Thickness	Depth, feet
Salt water and sand	16.5	955.5
Hard limestone	10.5	966
Limestone in hard and soft layers	22	988
Limestone with some sand	17	1005
Limestone	14	1019
Limestone with two shell layers	17	1036
Limestone with hard layers	15	1051
Limestone, very hard	13	1064
Limestone and sand	6	1070
Limestone, mostly hard	134	1204
Limestone	18	1222
Hard limestone	33	1255
Soft limestone	59	1314
Hard limestone	18	1332
Soft limestone	138	1470
Gray and brown sands	170	1640
Dark-brown sand	84	1724
Sand mixed with pebbles	26	1750
Light-colored sand	12	1762
Glauconitic sand	139	1901

That portion of the column from the surface to 465 seems to represent the Miocene and later formations. The main body of limestone from 465 to 1470 is apparently of Eocene, Oligocene and possibly basal Miocene age. The bottom of the well is probably in the Eocene. Casing was set at 460, 540 and 1900 feet.

Log of oil prospect well of Middle Georgia Oil and Gas Company, 12 miles west of Hazelhurst, Jeff Davis County

	Depth, feet
Mixture of quartz sand and yellowish clay	0–40
Fine-grained quartz sand with some clay	50
White, thinly laminated, arenaceous, micaceous clay	60
Fine quartz sand, loosely cemented by yellowish clay resembling fullers earth	65
Similar to 65	75
Similar to 65, except more clay	85
Similar to above	100
Similar to 65	110
Similar to 100	115
Similar to 100	120
Similar to 65	135–140
Gray arenaceous clay resembling fullers earth	140–165
Similar to 65	165–175
Similar to 65, with some gravel	175–182
Fine quartz sand and buff clay	182–185
Similar to 140-165	185–215
Similar to 65	215–220
Similar to 140-165	220–225
Similar to 182-185	225–236
Similar to 182-185	228–235
Similar to 140-165	236–250

Log of oil prospect well of Middle Georgia Oil and Gas Company, 12 miles west of Hazelhurst, Jeff Davis County—continued.

	Depth, feet
Quartz sand and gravel with phosphate pebbles and limestone fragments, cemented by calcareous binder. Nodosaria	278–282
Fine-grained quartz sand and phosphate pebbles cemented by gray, slightly calcareous clay	293–298
Similar to 293-298, with more sand	298–306
Fine quartz sand with phosphate pebbles, loosely cemented by buff clay	306–309
Buff clay with phosphatic sand	309–315
Phosphatic sand	319–322
Fine-grained phosphatic sand, with clay fragments, pieces of shells, and calcareous material	322–332
Similar to 322-332	332–338
Dark-gray calcareous clay, with shell fragments and phosphatic sand. Heat test shows odor of petroleum and trace of colorless oil	338–340
Phosphatic quartz sand	340–342
Similar to above, except some clay and calcareous material present	342–346
Soft, irregularly bedded buff-colored limestone with phosphatic sand and clay. Heat test gives petroleum odor and trace of oil	355–366
Similar to above	366–386
Shell and clay fragments, with phosphatic quartz sand cemented by calcareous binder	386–400
Similar to 306-309	400–405
Fine-grained quartz sand, with small fragments of shells, limestone, and flint	405–407
Fragments of shell, flint, and limestone, and phosphatic pebbles, together with fine, calcareous, quartz sand	407–409
Dark-gray calcareous clay with shell and lime fragments and some quartz sand. Numerous foraminifera, including Crystellaria	409–465
Hard, gray, calcareous sandstone and oyster shells	460
Soft, white limestone with fragments of shells and phosphatic quartz sand	460–480
Very dark-gray, slightly calcareous clay with small fragments of shells and some quartz sand	480–487
Light-gray quartz sand with a few shell fragments	487-503
Shell and limestone fragments and quartz sand cemented by calcareous binder; also dark-gray calcareous clay with shell fragments	503–520
Shell and limestone fragments and quartz sand loosely cemented by calcareous binder	520–530
Dark-gray, slightly calcareous, arenaceous clay with shell fragments; also fine quartz sand loosely cemented with clay	530–550
Quartz sand shell fragments, small pieces of limestone, and dark clay	565–580
Similar to above	585–590
Gray calcareous clay with fragments of shell and limestone	590–600
Fine quartz sand with some gray clay	600–620
Similar to above	610–615
Dark-Gray, slightly calcareous clay with fine quartz sand	620–630
Similar to above	630–645
Similar to above	645–650
Similar to above	650–665
Similar to above	665–675
Fine quartz sand and calcareous gray clay. Echinoderm spines abundant	685–690
Soft, light-buff, arenaceous limestone; echinoderm spines and Crystellaria	690–700
Similar to above	700–730
Soft, pure limestone; echinoderm spines and Crystellaria	730–740
Limestone with orbitoids, ostracods, and other indistinct foraminifera	740–745
Similar to above	745–755
Similar to above	755–765
Dark-gray clay containing sand, limestone fragments, and fossils similar to above	765–780
Light-yellow, soft, pure limestone with fossils similar to above	780–785
Similar to above	790–800
Soft white limestone with echinoderm spines, Crystellaria, and other indistinct fossils	800–825

Log of oil prospect well of Middle Georgia Oil and Gas Company, 12 miles west of Hazelhurst, Jeff Davis County—continued.

	Depth, feet
Soft, white, pure limestone with Nodosaria and other small indistinct forms	825–830
Similar to above	830–850
Pale-yellow pure limestone with echinoderm spines, orbitoids, and other indistinct forms	850–853
Soft, white, pure limestone; echinoderm spines, orbitoids, indistinct bryozoa, and other forms	853–864
Similar to above, orbitoids abundant	864–870
Light-yellow limestone; orbitoids, bryozoa and other indistinct forms	870–875
Soft, white, pure limestone; echinoderm spines and orbitoids abundant	885–910
Similar to above	910–920
Similar to above with gray clay	920–940
Similar to 885-910	940–950
Similar to above	950–955
Soft, pure, white limestone with abundant orbitoids	955–970
Similar to above	970–980
Soft, white, pure limestone; echinoderm spines and other indistinct fossils	980–985
Similar to above, except yellow in color	985–990
Soft, white, pure limestone; echinoderm spines and orbitoids abundant	990–1000
Similar to above, with some gray clay	1000–1010
Similar to above	1010–1020
Soft, pure, white limestone with abundance of orbitoids	1020–1027
Similar to above	1050–1060
White, pure limestone with abundance of Orbitoids and some echinoderm spines	1060–1070
Similar to above	1070–1080
Light-gray limestone; orbitoids and echinoderm spines in abundance, with a few bryozoa	1080–1090
Soft, white, pure limestone with fossils similar to above	1090–1100
Similar to above	1100–1105
White to light-gray limestone fragments with fossils similar to above and some quartz sand	1105–1115
Hard, gray, glauconitic sandstone, locally calcareous	1115–1120
Uncemented sand similar to above	1115–1130
Similar to above	1130–1150
Calcareous glauconitic quartz sand	1150–1160
Similar to above	1160–1170
Similar to above	1180–1190
Similar to above with less glauconite	1190–1200
White quartz sand	1200–1203
Glauconite quartz sand	1203–1210
Light-gray, fine-grained quartz sand	1210–1220
Similar to above with small amount of gray clay	1220–1230
Glauconitic quartz sand	1230–1240
Mixture of fine-grained quartz sand and calcareous gray clay	1240–1251
Dark-gray arenaceous marl	1255–1257
Similar to above	1255–1300
Large *Ostrea sp.*	1300
Similar to 1255-1300	1300–1320
Similar to above	1320–1330
Similar to above	1330–1345
Mixture of fragments of light-gray limestone and gray arenaceous marl	1345–1350
Similar to above	1350–1360
Gray, slightly argillaceous limestone with fragments of echinoderm spines and gastropods	1360–1370
Echinoderms and pelecyopods thought to be Cretaceous	1370–1375
Similar to above	1380–1390
Light-gray quartz sand with small fragments of limestone and marl	1390–1395

Log of oil prospect well of Middle Georgia Oil and Gas Company, 12 miles west of Hazelhurst, Jeff Davis County—continued.

	Depth, feet
Mixture of quartz sand, limestone fragments, and marl, with small fragments of fossils	1395–1400
Similar to above, with flint fragments	1411–1424
Lignite and very dark-gray clay	1425
Very dark-gray clay. Heat test gives odor of petroleum and trace of oil	1425–1428
Gray clay sand and oyster shells	1428–1432
White quartz sand with fragments of limestone marl and shells	1435–1445
Similar to above	1446–1448
Quartz sand, sandstone, and shell fragments, mainly oysters	1448–1453
Similar to above	1453–1460
Similar to above	1465–1470
Similar to above	1470–1485
Very dark-gray, arenaceous marl, with small fragments of limestone. Heat gives odor of petroleum and trace of oil	1485–1510
Similar to 1435-1445	1510–1535
Dark-gray, fine grained, calcareous, argillaceous sandstone	1535–1540
Similar to above, with fossil plant thought to be *Halymenites major*, (Cretaceous)	1550
Similar to 1435-1445	1545–1560
Similar to 1435-1445	1560–1570
Similar to 1435-1445	1580–1590
Similar to 1535-1540	1600–1607
Similar to 1535-1540	1607–1610
Similar to above, with more clay and few shell fragments	1615–1620
Similar to above	1620–1630
Arenaceous dark-gray marl, with few shell fragments	1630–1640
Similar to above	1640–1660
Similar to above	1660–1670
Similar to above but darker in color	1670–1695
Similar to 1535-1540	1690–1700
Concretionary quartzitic sandstone and siliceous limestone; young *Exogyra* (Cretaceous)	1700–1735
Dark-gray, very arenaceous marl. Heat test gives odor of petroleum and trace of oil	1735
Similar to above	1780–1800
Similar to above	1800–1805
Similar to above	1805–1815
Similar to above	1815–1825
Similar to above	1830–1975

The formation penetrated is probably Alum Bluff, down to about 690 feet although the thickness seems exeessive for this formation, and the lower part of this 690 feet may eorrespond to the Chattahooehee limestone of other areas, as the exact relation between the Chattahooehee limestone and basal Alum Bluff is not understood. The limestones from 690 to 1115 are thought to inelude the Glendon and Ocala formations. The euttings from 1370-1375, 1550 and 1700-1735 seem definitely Upper Cretaeeous in age. The Ripley apparently begins at about 1300, and the bottom of the well is probably in the lower part of the Ripley.

SUMMARY

Examination of the deep well logs of the Coastal Plain reveals a moderately uniform lithologic sequence in the formations penetrated throughout the province as a whole. There is reasonable evidence showing the lower part of the Ripley, or approximately the top of the Eutaw, as the lowest horizon reached, except in those wells close to the Fall line.

Following is a generalized columnar section representative of the Coastal Plain as a whole, exclusive of areas along its northern and western edges. The thicknesses given are in part estimates only, and not observed thicknesses. In general the formations thicken toward Brunswick, which is shown to be in a structural trough.

Generalized Columnar Section of the Coastal Plain of Georgia

Formation	Thickness (Feet)	Character of beds
Alum Bluff	0 to 350	Sand and clay, with basal limestone and flint lenses.
Chattahoochee Glendon Ocala	0 to 1300	White to yellow, fossiliferous, soft limestone, with local flint layers.
Claiborne Wilcox Midway	0 to 400	Sand, clay, and marl, with lenses of limestone.
Ripley / Undif. Eutaw / Upper Cret. Lower (?) Cretaceous	0 to 2000	Gray, arenaceous marl and fine sand, with basal members of gravel, cross-bedded arkosic sand, and clay lenses.
Crystalline		

STRUCTURAL CONDITIONS IN THE COASTAL PLAIN OF GEORGIA

METHODS EMPLOYED IN DETERMINING STRUCTURES

The Coastal Plain of Georgia has been more or less arbitrarily divided into three structural areas or subdivisions, for the purpose of more readily handling the structural data. These areas are here termed areas No. 1, No. 2, and No. 3. Area No. 1 approximately coincides with the physiographic subdivision of the Coastal Plain known as the Fall-line hills belt. Area No. 2 is approximately coincident with the Dougherty plain. Area No. 3 embraces the Altamaha upland, the Southern lime-sink region, the Okefenokee plain, and the Satilla coastal lowland. (See map II.)

In areas Nos. 1 and 2 the methods of determining the structural conditions are based primarily on a study of the general areal geology and topography taken jointly. Stream data, direction and elevations are likewise used. Other factors of lesser importance have been used wherever applicable. It is desirable to discuss area No. 2 separately because the distribution of formations, as shown on the geologic map, suggests folding, whereas it can be shown that the distribution is due to a combination of lithology and topography, and not to abnormal structure.

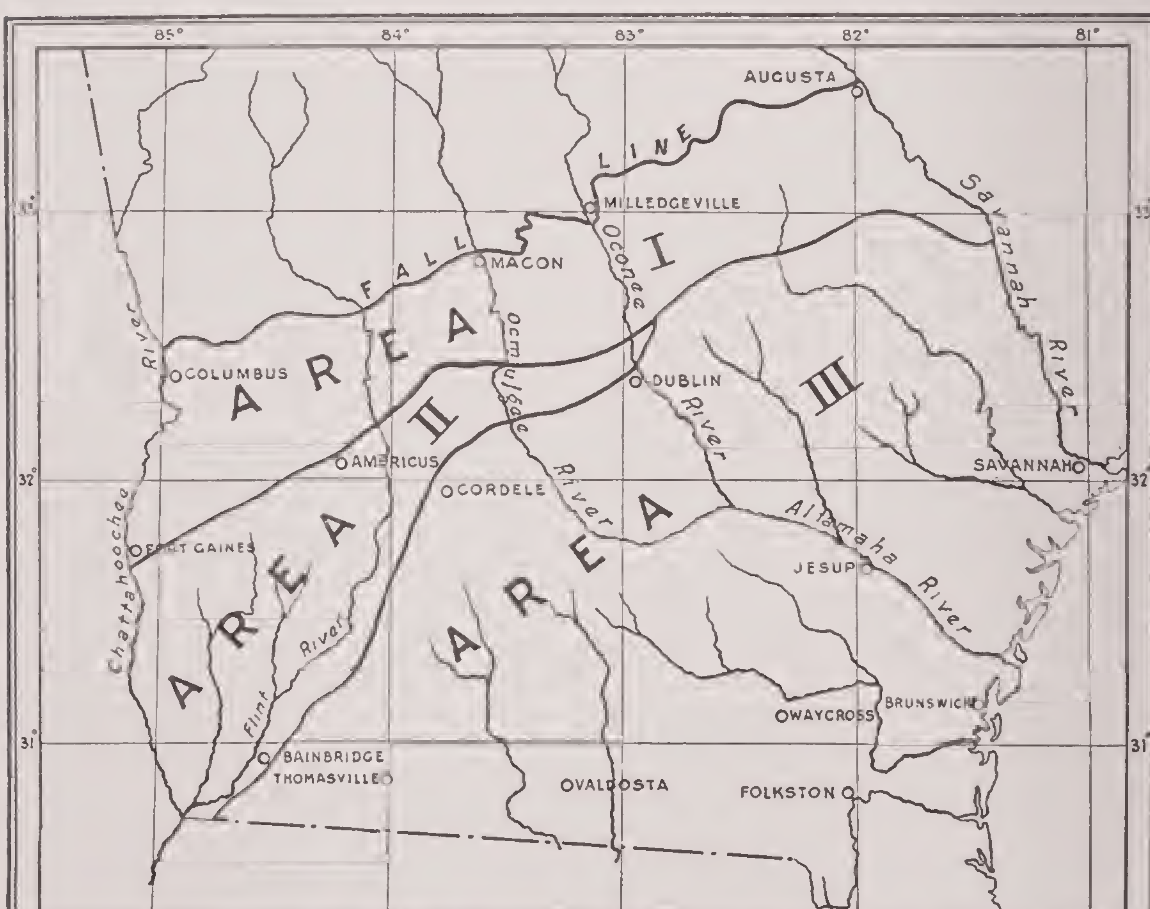
The work in area No. 3 involved methods not applicable to the other two areas. In this area the interpretation of structure is based on data collected from well logs and outcrops, general geology and topography, drainage conditions, and underground water conditions. A separate discussion of each area follows:

STRUCTURAL AREA No. 1

Structural area No. 1 comprises a belt, approximately 40 miles wide, lying immediately south of the Fall line and extending entirely across the State from Augusta to Columbus. Throughout this area the thickness of sediments overlying the crystalline rocks

varies from zero at the Fall line to about 1500 feet along its southern edge. As the sediments in the northern part of the area are very thin and contain no oil or oil-forming matter in quantity, this part of the area can be eliminated at once from consideration as a possible source of production. Since the beds are lenticular and unconsolidated the determination of structural details is very difficult. The beds, as previously described, are mainly arkosic, micaceous, cross-bedded sands, and clays, with commercial deposits of kaolin and gravel, all free from matter capable of forming oil.

Rapid lateral variation and the general unconsolidated nature of the deposits would generally prevent the detailed determination of structural conditions, and even if such were possible they would be unwarranted by the close proximity of the area to the Fall line.



Map II.—Structural area of Coastal Plain of Georgia

Throughout the southern part of this structural area the sediments are rather thin, but not so thin as to condemn entirely the area with reference to possible oil production. The presence of numerous streams flowing southeastward across the belt furnish excellent geologic and topographic data which show that the regional dip is southeastward. The older beds disappear regularly below water and fail to reappear farther downstream. The monoclinal southeast dip shown in Map III is also indicated by artesian water conditions.

Detailed work has been done in some areas and some small interruptions in the monoclinal attitude have been observed, as near Green's Cut, in Burke County. It is probable that the uneven settling of unconsolidated sediments on the irregular surface of the crystaline floor, close beneath, might cause folding without dynamic movement. Sufficient work over area No. 1 has been done to show the absence of folding of magnitude.

STRUCTURAL AREA No. 2

The regional structural conditions of area No. 2 may be generally described as monoclinal with a dip to the southeast. The lack of satisfactory key horizons—because of similarity of strata, rapid lateral variation, numerous unconformities, slumping, and the general unconsolidated nature of most of the exposed beds,—prohibits the determination of local structural details throughout the area. The general attitude of the formations, however, is revealed by areal geology, topography, static head of ground water, and the attitude of a few recognizable broad horizons in the geologic column.

The Glendon formation unconformably overlies the Ocala limestone along Flint River all the way from Faceville, in Decatur County, to a point about 10 miles south of Oglethorpe. Throughout this distance the contact is practically parallel to water level. The Ocala disappears below water near Faceville and does not reappear down stream. Thus there is evidently an absence of post-Glendon folds of any consequence crossing the Flint between a point 12 miles south of Oglethorpe, over a straight-line distance of about 110 miles.

Also, the regular manner in which the Ocala along the general line of the Flint disappears beneath the Glendon and fails to reappear southeastward points to a similar regular monoclinal attitude throughout the Glendon outcrop over the Flint River belt lying generally just east of the river. And too, the regularity of static head of ground water, as indicated by flowing wells, tends to confirm the monoclinal attitude of the beds.

Throughout the irregular Glendon belt extending from Cordele to Fort Gaines, the fact that the underlying Claiborne and Ocala are exposed only along the main water courses points to a normal monoclinal attitude of the beds dipping gently southeastward. Artesian conditions tend to confirm this attitude over the southeastern portion of this area.

The area of Ocala outcrop, roughly including a large part of Seminole, Early, Miller, Baker, Calhoun, Dougherty, and Lee counties, and bordered on both the northwest and southeast by Glendon areas, might, on casual inspection of the areal distribution of formations, be considered indicative of a closed regional uplift exposing an older formation with younger beds on each side. Examination of the topography of the area shown on map III, however, shows that the feature is topographic only and not structural, the Glendon simply having been eroded from above the Ocala, exposing the latter at its normal elevation. The regular disappearance of the older formations along the Chattahoochee River beneath the younger formations as we pass down stream, together with the regular artesian water conditions along the main streams, similarly indicate a normal regional dip to the southeast. Failure of Claiborne beds to appear at the surface throughout this Ocala area furnish additional evidence that the beds are monoclinal. This evidence is more weighty in the northwestern part of the area, where the Ocala is thin, than throughout the southeast part, where greater movement would be required to expose the Claiborne.

Throughout the portion of area No. 2 east of the Flint River the

topography, areal geology, and artesian water all indicate the normal monoclinal attitude of beds dipping southeastward.

Altitudes of the bottom of the Glendon, taken at a number of points, indicate a general southeastward dip of about 8 feet per mile.

Stream data throughout area No. 2 have been regarded as probably indicative of a regional anticline with axis along the Chattahoochee River, but with the evidence now available no such structural feature is thought to exist. Some gentle regional Pleistocene or later movement is shown by the terraced river valley, and some slight irregularity of dip is observed, as at a point on the river opposite Gordon, Alabama, where there is a slight local reversal of dip upstream, but no folding of magnitude is indicated, and there seems no evidence of a western reversal of the regional monoclinal dipping to the southeast.

The Flint river is apparently confined to its present course by the Alum Bluff escarpment on the east, shown by the topographic map. The tributaries of the Flint entering from the east flow up regional dip and drain only the steep western slope of the escarpment, and consequently are very short. The western tributaries of the Flint flow down regional dip, but the eastern Chattahoochee tributaries north of the mouth of the Flint have an appreciable component in direction away from regional southeast dip. Thus it is quite natural that the eastern Chattahoochee tributaries, similar to the eastern Flint tributaries, should be shorter than the western tributaries of the Flint.

It is likewise normal that topographic elevations along the crest of the Alum Bluff escarpment should be higher than the south and central portions of the Dougherty plain on the west, where erosion, assisted by solution and weathering of limestone, has removed the younger formations, thereby greatly lowering the surface elevation.

STRUCTURAL AREA No. 3

The structural area or unit designated area No. 3 includes the physiographic subdivisions of the Coastal Plain of Georgia known as the Altamaha upland, the Southern lime-sink region, the Okefenokee plain, and the Satilla coastal lowland. This area is by far the largest of the three structural areas, and includes approximately two-thirds of the Coastal Plain.

Throughout practically the whole of area No. 3 the surface outcrops are of the Alum Bluff, Charlton, Okefenokee, and Satilla formations. Along the inland limits of the area, and in the south-central and southwestern corner of the State, older formations are exposed. It thus develops that over the greater part of the area the only outcrops that can be used for determining structural conditions belong to the formations above enumerated.

Because the Charlton, Okefenokee, and Satilla formations are unconsolidated, occupy small areas, and are superficial, they are unfit for determining existing structural conditions.

The Alum Bluff formation on first examination might appear to furnish outcrops upon which structural data might be collected. Over large areas the upper portion of the Alum Bluff consists of very locally indurated beds of sand and clay. Attempts have been made to use such outcrops, but a careful study of them has revealed their unsuitability for key rocks. Where good exposures of the indurated upper portion of the formation can be studied along many of the larger streams, the beds change laterally in lithologic character very rapidly, and nowhere do either the indurated sands or clays represent continuous beds, nor are they, therefore, of value as definite horizon markers. Added to this is the fact that the indurated parts nearly always represent the higher topographic areas. They are higher because they are hard and weather less rapidly than softer beds. From all the data available the writers are therefore convinced that these resistant portions have been indurated subsequent to deposition, and do not represent any definite horizon or bed which

can be used for determining existing structural conditions. Moreever, at no point within the Alum Bluff formation do any definite horizons appear, either as outcrops or from well logs, that can be definitely recognized and correlated from point to point.

In view of the above facts the writers have selected as a key a horizon near the base of the Alum Bluff formation, which may be defined as the base of the widespread greenish to bluish clay, commonly termed blue marl by drillers of the area. The base of this blue marl may not mark the exact base of the Alum Bluff, but from all available data it does apparently represent the beginning of a widespread and uniform condition of deposition over practically the whole of the area, and thus appears to represent a trustworthy basis for determining regional structural conditions. Moreover, this blue marl nearly everywhere rests upon calcareous deposits of a decidedly different lithologic character, its base thereby being readily recognized in wells and at the exposed contacts along the inland and southwestern limits of the area.

At or near the northern, western, and southwestern limits of the Alum Bluff area numerous exposures of the key bed have been examined, and throughout the remainder of the area approximately 500 well logs have been collected from various sources. Of the surface exposures 24 of the best were selected for use. In places several exposures are close together, and in such cases, where the data were in close agreement, only one exposure is listed. The well logs were very carefully studied and the value of each weighed on the basis of the character of the log, whether oral or written, and as to the general reliability of its source. Only the best logs were selected. So many of the well data from neighboring wells were found to be in such close agreement that composite logs for the immediate region are set forth, rather than giving many logs for a small area. The composite records for areas are thus listed in this bulletin as single logs. On the basis of these composite data taken as single units, together with the individual logs finally selected, 54 well logs are given

for this area. This number undoubtedly appears to be small, but considered from the point of their careful selection, their general reliability, the composite logs, and numerous other logs which are in good agreement but which are not published, the writers feel that the number thus presented is sufficient to show the regional structure of the area. At no place in area No. 3 are the available well data sufficient to permit local structural details to be accurately determined.

The method for ascertaining the structural determination was to locate at each well and at each outcrop the altitude of the key horizon as accurately as possible with respect to sea level. For the outcrops this was done by taking their altitudes. For the wells the surface elevation of the well was recorded and this figure, in conjunction with the depth to the key horizon, gave the relation of the key to sea level. Points of equal altitude were then connected by structure contour lines at intervals of 100 feet. In one case only was a fifty foot interval used, and that was for the reason that the data were such as to warrant the drawing of a 150 foot contour in order to better illustrate structural conditions. (See Map III.) In some cases all the available data were so meagre that the structure contours had to be drawn on the basis of interpolation between somewhat widely separated points. It is believed, however, that the limit of error is not so great as might at first appear.

The structure contour lines show that for the greater part of area No. 3 there is a general monoclinal dip of the key horizon, the dips being south, southeast, east, and northeast, thus forming nearly half of a broad, gentle circular structural basin whose general center appears to be in the Brunswick area. The term circular is used only to express the curvature of the structural lines, as no closure is known to exist east of the coast line.

In this segment of structural basin the greatest irregularity in the structure contours appears in the region roughly outlined by a line drawn through the towns of Douglas, Broxton, Osierfield, and Ocilla,

and may indicate local structural high. Detailed data to confirm this are lacking.

In the southwestern part of area No. 3 the structure contour lines show a departure from their general direction over the rest of the area, and in Grady, Thomas, Colquitt, Brooks, Cook, Lowndes, and Echols counties they show a change in structural conditions. By the direction of the contours a gentle southward-plunging structural arching is shown. This arch has a south—southeast direction and its approximate axis extends roughly from the Florida State line through the towns of Metcalf and Thomasville towards Camilla.

Extending from Valdosta east and southeast through the area between Statenville and Thelma is apparently a structural crest, the key horizon dipping northeast and southwest from it. Between this crest and the arch to the west there is a gentle syncline. Both this syncline and the arch to the west of it, as well as the crest itself, may be a reflection from the known structural high of the Live Oak, Florida, region.

ELEVATIONS

On the following pages is given a list of the elevations used for determining the location of the structural contour lines as drawn on Map III. These elevations include those determined from surface exposures and from well logs.

CONTACT OUTCROP ELEVATIONS

Elevations on surface exposures of contact of Alum Bluff green clay with underlying Glendon or Chattahoochee formation

	Elevation, feet
BROOKS CO.:	
1. Devil's Hopper, 2 mi. NE. of Barwick	135
2. Haddock place, 8½ mi. S.-SW. of Quitman, on Monticello Rd.	125

Elevations on surface exposures of contact of Alum Bluff green clay with underlying Glendon or Chattahoochee formation—continued.

Elevation, feet

CRISP CO.:
- 3. Rock House, 3.3 mi. E.-NE. of Wenona ---------- 347

DECATUR CO.:
- 4. Powell lime sink, 8½ mi. east of Bainbridge, upper Thomasville Rd. ---------- 165
- 5. Falling Water, 1½ mi. west of Recovery, on Railroad, and 12½ mi. west of Faceville ---------- 120

DOOLY CO.:
- 6. Five and one-half miles SE. of Vienna, on Rochelle Rd. ---------- 384

ECHOLS CO.:
- 7. Allapaha River, 1 mi. below Statenville ---------- 90

GRADY CO.:
- 8. Forest Falls, 8 mi. north of Whigham ---------- 190
- 9. James Blackshear place, 8 mi. south of Cairo, east bank of Ochlocknee River ---------- 150

LAURENS CO.:
- 10. Dublin, SE. part of town ---------- 215

LOWNDES CO.:
- 11. One hundred yards below wagon bridge, 3 mi. below G. & F. trestle over Withlacoochee River ---------- 95

MITCHELL CO.:
- 12. Haygood place, 5 mi. N.-NW. of Sales City ---------- 260
- 13. Six mi. east of Camilla, on Moultrie Rd. Foot of Alum Bluff escarpment ---------- 260

SCREVEN CO.:
- 14. Five miles NE. of Sylvania, on Brier Creek ---------- 90

THOMAS CO.:
- 15. M. D. McKinnon place, 5 mi. east of Thomasville, ¼ mi. south of Boston Rd. ---------- 180
- 16. Original Pond, 11 mi. south of Thomasville, 4 miles west of Metcalf ---------- 175
- 17. A. H. Hough place, 11½ mi. SW. of Thomasville, on Springhill Rd. ---------- 170

TURNER CO.:
- 18. One mile NE. of Dakota ---------- 335

WILCOX CO.:
- 19. Lime sink, 9 mi. S.-SW. of Abbeville, on Center School Rd. ---------- 180
- 20. Jordan's Landing, Ocmulgee River, 6 mi. SE. of Abbeville ---------- 173
- 21. Five and seven-tenths miles north of Rochelle, on Hawkinsville Rd. ---------- 325

WORTH CO.:
- 22. Three miles NW. of Bridgeboro, at Indian Cave, on Albany Rd. ---------- 285

Elevations on surface exposures of contact of Alum Bluff green clay with underlying Barnwell formation

Elevation, feet

EMANUEL CO.:
- 23. Two and one-half miles SW. of Midville, on E. Cross place ---------- 181

JENKINS CO.:
- 24. Four miles north of Millen, on Buckhead Creek, at mouth of Spring Mill Branch ---------- 155

Well data used in making structural map.

No.	Depth.	Location.	Driller.	Authority.	Basis.	Surf. elev.	Depth to key.	Elev. key hor.	Quality of water.
		Appling Co.							
1	426′	Baxley		Dr. Comas	Oral	206′	426′(?)	—220′(?)	Soft at—208′
		Ben Hill Co.							
2	280′	Fitzgerald	W. R. McGrew	Driller	Written	350′	242′	+108′	Hard
		Berrien Co.							
3	240′	Nashville	W. R. McGrew	Driller	Written	250′	200′	+50′	Hard
4	680′	Allapaha	W. R. McGrew	Driller	Oral	293′	230′	+63′	Hard
		Bryan Co.							
5	325′	Keller	A. E. Cory	G. W. Corson	Oral	15′	310′	—295′	Sulphurous
6		Pembroke			Oral	94′	250′	—156′	
		Bulloch Co.							
7	555′	Statesboro	Hughes Specialty Well Drilling Co.	J. R. Connelly	Written	220′	330′	—110′	Hard
8	390′	Portal		B. E. Smith	Oral	294′	300′	—6′	Hard
9	360′	Register	G. E. Green	Driller	Oral	171′	280′	—109′	Hard
		Camden Co.							
10		Composite for SE, ¼ of County	Fred Baumgardner	Driller	Oral	20′	490′	—470′	Hard
		Charlton Co.							
11		Folkston	H. C. Russell	W. M. Ollif	Oral	81′	510′	—429′	Hard
		Chatham Co.							
12	240′	Savannah		T. M. Prettyman	Written	20′	240′	—220′	Hard
		Clinch Co.							
13		Thelma	Frank Fletcher	Driller	Oral	158′	18′	+140′	Hard
		Coffee Co.							
14	520′	1¼ mi. E. Douglas Col. O'Stein well	J. F. Wooten	Driller	Written	250′	280′	—30′	Hard
15	396′	9¼ mi. N.--N.E. Douglas, W. M. Harden well	J. F. Wooten	Driller	Written	250′	233′	+17′	Hard
16	300′	7½ mi. E. Douglas, Jeff Lewis well	J. F. Wooten	Driller	Written	225′	295′	—70′	Hard
17	260′	4 mi. S. Broxton, Elijah Lot well	B. F. Malone	Driller	Oral	230′	200′	+30′	

Well data used in making structural map—(continued).

No.	Depth.	Location.	Driller.	Authority.	Basis.	Surf. elev.	Depth to key.	Elev. key hor.	Quality of water.
		Cook Co.							
18	272′	Adel		J. B. Spencer	Oral	246′	172′	+74′	Hard
		Dodge Co.							
19	210′	Chauncey	Robt. Murray	Driller	Written	300′	184′	+116′	Hard
20	206½′	Consolidated School, 4 mi. N. Eastman	J. F. Wooten	Driller	Written	360′	135′	+225′	Hard
21	408′	6 mi. S.W. Eastman, R. F. Burch Sr. well	J. F. Wooten	Driller	Written	350′	140′	+210′	Hard
22	115′	8 mi. W. Eastman, Wm. McRae well	J. F. Wooten	Driller	Written	310′	87′	+223′	Hard
23	40′	11 mi. S. Cochran		T. M. Prettyman	Written	315′	15′	+300′	Hard
		Effingham Co.							
24	400′	Guyton, W. T. wells		S. W. McCallie	Oral	80′	200′(?)	—120′(?)	Sulphurous
		Evans Co.							
25	546½′	Claxton, N. H. Thaggard	Hugh Specialty Well Drilling Co.	U. S. G. S.	Written	187′	310′(?)	—123′(?)	
		Glynn Co.							
26		Brunswick area, composite	Baungardner, Wade Perry, Linniman	Drillers	Written & Oral	10′	500′	—490′	Hard Sulphurous
27	460′	Everett City			Oral	16′	440′(?)	—424′(?)	Hard Sulphurous
		Irwin Co.							
28	512′	Ocilla, Oskamp well		S. W. McCallie		327′	300′(?)	+27′(?)	Hard
29	330′	Osierfield	B. F. Malone	Driller	Oral	350′	330′	+20′	Hard
		Jeff Davis Co.							
30	828′	8 mi. S.W. Hazelhurst Oil Prospect well		L. F. Hinson	Oral	256′	400′	—144′	
31	1975′	12 mi. W. Hazelhurst Lillian B. No. 2		T. M. Prettyman	Written	225′	350′	—125′	
		Laurens Co.							
32		Cadwell Two wells		Mayor	Oral	335′	195′	+140′	Hard

Well data used in making structural map—(continued).

No.	Depth.	Location.	Driller.	Authority.	Basis.	Surf. elev.	Depth to key.	Elev. key hor.	Quality of water.
		Liberty Co.							
33	400′±	Fleming area, composite				22′	360′	—338′	Hard
34	546′	Allenhurst	Hughes Specialty Well Drill Co.		Written	60′	440′	—380′	Hard
		Liberty Co.							
35	438′	St. Catherine Island	W. J. Floyd	Driller	Written	10′	432′	—422′	Hard
36	500′±	Riceboro area, composite			Oral	15′	375′	—360′	Hard
		Lowndes Co.							
37	500′±	Valdosta area composite	J. A. Durst, G. C. Reynolds, W. R. McGrew	Drillers	Oral	215′	90′	+125′	Hard
38		Hahira	John Collins	Driller	Oral	230′	125′	+105′	
		McIntosh Co.							
39	420′	Eulonia	F. L. Perry	V. R. McIntosh	Oral	15′	420′	—405′	Hard Sulphurous
40	425′	Jones	Perry & Duke	Fulton	Oral	20′	415′	—395′	Hard Sulphurous
41	471′	Meridian	Perry & Duke		Oral	20′	471′	—451′	Hard Sulphurous
		Pierce Co.							
42	675½′	Offerman, So. Pine Lumber Co.	Hughes Specialty Well Drilling Co.	Drillers	Written	106′	420′	—314′	
		Screven Co.							
43	100′+	Rockyford composite	Dan Aycock	Driller	Oral	124′	85′	+39′	Hard
		Telfair Co.							
44	222′	Helena, Coca Cola Co. well	J. F. Wooten	Driller	Written	242′	210′	+32′	Hard
45	465′	Scotland Telfair Oil Co.		T. M. Prettyman	Written	130′	180′	—50′	Hard
46	294½′	Lumber City Max McRae well	Robt. Murray	Driller	Written	146′	273′	—127′	Hard
		Tift Co.							
47	283′	Tifton town well	Hughes Specialty Well Drilling Co.	Driller	Written	370′	212′	+158′	Hard
48	280′	Cyclonета, W. A. Greer	B. F. Malone	Driller	Oral	410′	190′	+220	Hard
		Toombs Co.							
49	500′+	Vidalia Composite	Robt. Murray, J. F. Wooten	Drillers	Written	310′	434′	—124′	Hard

Well data used in making structural map—(continued).

No.	Depth.	Location.	Driller.	Authority.	Basis.	Surf. elev.	Depth to key.	Elev. key hor.	Quality of water
		Ware Co.							
50	691′	Waycross city well	B. D. Finn	S. W. McCallie	Written	140′	415′	—275′	
51	3045′	Fredel, Waycross Oil & Gas Co.		T. M. Prettyman	Written	130′	435′	—305′	
		Wayne Co.							
52	1901′	Doctortown, Oil Prospect well		C. A. Gibson	Written	95′	465′	—370′	
53	560′	Mt. Pleasant, So. States Pine Products Co.	Hughes Specialty Well Drilling Co.	J. R. Connelly	Written	55′	476′	—421′	
		Worth Co.							
54	20′	Willingham		T. M. Prettyman	Written	315′	10′	+305′	

LOGS OF WELLS USED IN DETERMINING STRUCTURE CONTOUR LINES

APPLING CO.:

	Feet.
1. Baxley:	
Blue marl and sand	0–208
Shell and sand alternating	208–426
Limestone	426– ?

BEN HILL CO.:

2. Fitzgerald, partial log of City Water Works well:	
Yellow clay	0–10
Red clay	10–16
Water-bearing sandstone, coarse	16–20
White clay with sand	20–45
White marl	45–65
Coarse sandstone. Water	65–70
White marl and sandstone layers	70–115
Sticky brown marl	115–183
Limestone	183–225
Soft clay	225–230
White marl	230–242
Porous limestone	242–260
Hard limestone	260–280
Flinty limestone	280– —

BERRIEN CO.:

3. Nashville, city well:	
Red clay	0–20
Red sandstone	20–55
White marl	55–85
White sand	85–100
White marl	100–130
Streaks soft rock and white marl	130–200
Brown limestone, alternating hard and soft	200–240
Two feet cavity and water at	240–
4. Allapaha, Mill well:	
Mainly sand	0–230
Limestone	230–680

BRYAN CO.:

5. Keller, town well:	
Sand	0–20
Mud and gravel	20–50
Greenish marl (clay and sand)	50–70
Shale rock	70–72
Sand, shale rock, and hard marl	72–310
Limestone, water-bearing	310–325
6. Pembroke, generalized:	
Sand and clay	0–250
Limestone, water-bearing	250–

BULLOCH CO.:

7. Statesboro, town well No. 2:	
Soft yellow sand and clay alternating	0–40
Light-colored hard sandstone	40–70
Light-colored soft sand	70–80
Light-colored marl and sand	80–100

Log of wells used in determining structural lines—continued

	Feet.
Light-colored chalky material	100–120
Light-colored tough rock	120–140
Light-colored soft sand	140–160
Tough light-colored rock and sand in layers	160–220
Light-colored hard rock	220–240
Tough light-colored rock and sand in layers	240–280
Soft chalky material	280–330
Hard white rock	330–360
Medium-hard, white sand and rock in layers	360–400
Medium-hard, dark-brown shell rock, water-bearing	400–460
Light-brown shell rock, interbedded shell layers, water-bearing	460–555
8. Portal, B. E. Smith well:	
Sand and clay	0–300
Limestone	300–390
9. Register:	
Sand and clay	0–120
Blue marl	140–280
Hard white rock, alternating with water-bearing sand	280–360
CAMDEN CO.:	
10. Southeastern quarter of County, generalized:	
Sand and blue marl	0–480
Limestone	480– ?
CHARLTON CO.:	
11. Folkstone, town well:	
Sand and blue marl	0–510
Water-bearing horizon at	510–
CHATHAM CO.:	
12. Savannah, city well, generalized:	
Sand, clay and marl	0–240
Soft porous limestone	240– ?
CLINCH CO.:	
13. Thelma:	
Sand	0–18
Limestone, water-bearing	18– ?
COFFEE CO.:	
14. Douglas, O'Stein well, 1 mi. NE. of town, generalized:	
Red to white sand and clay	12–65
Blue shale and sand	65–141
Hard white and yellow rock	141–153
Red clay	153–165
White to yellow limestone	165–200
Soft white shale	200–280
White to yellow limestone, hard and soft alternating	280–520
15. W. M. Harden, 9½ mi. N.-NE. of Douglas, generalized:	
Red to gray clay and sand	3–118
Soft blue shale	118–228
Soft white sand. A little water	228–233
White to yellow limestone, hard and soft	233–396
16. Jeff Lewis, 7½ mi. east of Douglas, generalized:	
Gray to red sand and clay	8–190
Hard and soft blue shale	190–295

Log of wells used in determining structural lines—continued

	Feet.
Soft yellow rock (limestone?)	295–300
17. Elijah Lot, 4 mi. south of Broxton (Douglas Rd.):	
Sand and clay	0–200
Limestone	200–260
COOK CO.:	
18. Adel, town well (partial record):	
Sandy soil	0–2
Red clay	2–12
White sand	12–22
Blue clay with sandstone boulders	22–147
Fine white sand	147–172
Limestone with thin layers of flint; water-bearing at 229.	172–272
DODGE CO.:	
19. Chauncey, Warehouse & Mfg. Co., generalized:	
Sand and clay	0–146
Blue shale and sand	146–184
Soft limestone with small amount of clay	184–210
20. Consolidated School, 4 mi. north of Eastman, generalized:	
Red to dark sand and clay	0–55
Gray and blue sand and shale	55–135
White to yellow limestone, hard and soft	135–206
21. R. F. Burch, Sr., 6 mi. SW. of Eastman, generalized:	
Clay and sand, white, red and yellow	0–100
Blue clay and shale	100–140
Hard yellow limestone	140–408
22. Wm. McRae, 8 mi. west of Eastman, generalized:	
Red and white clay and sand	0–59
Blue shale	59–87
Yellow limestone	87–115
23. W. P. Holder, 11 mi. south of Cochran, on Eastman Rd. (dug well):	
Sand and clay	0–15
Limestone	15–40
EFFINGHAM CO.:	
24. Guyton, J. T. Wells:	
Clay	0–200
Rock	200–201½
Rock in beds. Sharks teeth and shells	201½–396
Quicksand	396–400
EVANS CO.:	
25. Claxton, N. H. Thaggard, generalized:	
Sand, marl and rock	0–310
Hard white rock	310–350
Fine white sand	350–365
Hard brownish limestone with nummulites and orbitoids, including sp. cf. O. stellata. Cuttings 365-370 appear definitely Ocala. Top of Chattahoochee probably at 310, giving 55 feet of Oligocene	365–370

Log of wells used in determining structural lines—continued

	Feet.
GLYNN CO.:	
26. Brunswick area, composite:	
Sand, clay and marl	0–500
Limestone	500– ?
27. Everett City, generalized:	
Sand and marl	0–440
Limestone	440–460
IRWIN CO.:	
28. Ocilla, Ensign Oskamp Co.:	
Sand and clay	0–60
Soft rock	60–76
Sand	76–105
Rock	105–300
Very hard rock	300–312
Porous limestone with cavities 4 feet deep	312–512
29. Osierfield:	
Red sandstone and clay	0–100
Rock	100–160
Sand	160–230
Blue clay, with some limestone	230–330
Main body of limestone at	330.
JEFF DAVIS CO.:	
30. Oil prospecting well 8 mi. SW. of Hazelhurst:	
Surface clay and sand	0–25
Soft clay and sand	25–225
Blue clay and sand	225–400
Hard rock (limestone), shells at top	400–415
Principally limestone	415–815
Black sandstone	815–828
31. Lillian B. No. 2, 12 mi. west of Hazelhurst (partial log), generalized:	
Sand and clay	0–350
Limestone	350–400
Clay, limestone, sand, and marl	400–700
Limestone	700–1140
32. Cadwell, two wells, composite:	
Sand, clay and rock	0–200
Limestone	200– ?
LIBERTY CO.:	
33. Fleming area, composite of numerous wells:	
Sand, clay and flint	0–360
Limestone	360– ?
34. Allenhurst, Byers-Allen Lumber Co., generalized:	
Clay, sand and rock	0–440
Limestone and shell	440–546
35. St. Catherine Island:	
Sand	0–38
Coarse sand with gravel and shells	38–41
Sand	41–230
Greenish marl	230–310
Grayish marl	310–385

Log of wells used in determining structural lines—continued

	Feet.
Marl and layers of soft rock. First flow at 398	385–398
Marl and layers of rock. Flow at 432	398–438
36. Riceboro area, composite, generalized:	
Clay, sand and rock	0–375
Main limestone	375– ?
LOWNDES CO.:	
37. Valdosta area, composite, generalized:	
Yellow sand, clay and blue marl	0–90
White to yellow, hard and soft limestone	90–500
38. Hahira, town well, generalized:	
Sand, clay and blue marl	0–125
White limestone	125– ?
McINTOSH CO.:	
39. Eulonia:	
Sand and red clay	0–40
Sand and clay	40–300
Hard flint layer	300–301½
Blue marl	301½–420
Limestone	420– ?
40. Jones:	
Clay, sand, and blue marl	0–415
Limestone	415–425
Stopped in limestone.	
41. Meridian:	
Clay, sand, and blue marl	0–471
Limestone at 471.	
PIERCE CO.:	
42. Offerman, Southern Pine Lumber Co., generalized:	
Sand, light clay and blue marl	0–420
Medium to hard, white and yellow limestone with some coarse gray sand	420–675½
SCREVEN CO.:	
43. Rocky Ford, composite:	
Sand and clay	0–85
Limestone, hard water	85– ?
TELFAIR CO.:	
44. Helena, Coca Cola Bottling Works:	
Sandy loam	0–7
Red clay, streaks of pipe clay	7–27
Sluffy, sandy shale, streaks of pipe clay	27–101
Soft sandy shale, fossils	101–124
Sandstone	124–128
Soft sandy shale	128–160
Soft shale	160–165
Hard sandstone	165–168
White sandy clay	168–180
Hard blue shale	180–200
Very hard flint lime rock	200–210
Medium-hard limestone	210–222

Log of wells used in determining structural lines—continued

45. Scotland, Telfair Oil Co., generalized:

	Feet
Sand	0–180
Limestone	180–465

46. Lumber City, M. L. McRae:

	Feet
Sand	0–5
Clay	5–22
Sand	22–32
Red clay	32–37
Blue shale	37–173
Shell rock	173–175½
Blue shale	175½–198½
Hard rock	198½–199½
Blue shale	199½–269½
Hard rock	269½–273½
Vein	273½–274
Rock	274–276
Vein	276–276½
Porous rock	276½–294½

TIFT CO.:

47. Tifton, town well, generalized:

	Feet
White sand and clay, some flint	0–135
Light-gray, argillaceous, calcareous sand	135–150
Quartz sand and calcareous sand	150–212
White sandy limestone (probably Chattahoochee, according to U. S. G. S.)	212–278
Flint	278–283

48. Cycloneta, W. S. Greer:

	Feet
Clay and rock	0–150
Rock and sand	150–190
Solid limestone	190–280

TOOMBS CO.:

49. Vidalia, Ice Co., composite of two wells, generalized:

	Feet
Alternate clay and sand	0–168
Rock, sand and blue clay	168–434
Rock lime	434–511

Note: Almost exact agreement between two wells drilled by different men several years apart.

WARE CO.:

50. Waycross City well, generalized:

	Feet
White sand and red to white clay	0–185
Marl, blue clay, and sand alternating	185–380
Shells and shell marl	380–415
Highly fossiliferous limestone; Tampa horizon at	415.
Mainly limestone, some sand and clay	415–691

51. Fredel, Waycross Oil & Gas Co., generalized:

	Feet
Sand and some clay	0–435
Limestone with some flint	435–855
Sand	855–1278
Limestone	1278–2115
Marl	2115–2163
Sand with some clay	2163–3045

Log of wells used in determining structural lines—continued

WAYNE CO.:

	Feet
52. Doctortown, oil prospecting well, generalized:	
Sand with some clay	0–320
Limestone, flint and marl	320–465
Limestone	465–1462
Sand with some clay	1462–1901
53. Mt. Pleasant, Southern Pine Products Co., generalized:	
Gray sand and clay	0–115
Sandy clay, sand, and calcareous sand	115–476
White sandy limestone, water in lower 20 feet	476–560
WORTH CO.:	
54. Willingham, dug well on north side of R. R., 100 yrds. east of Station:	
Sand	0–10
Limestone	10– ?

GENERAL STRUCTURAL EVIDENCE

Evidence in support of the regional structure of area No. 3 is afforded by areal geology together with the general topographic conditions. (See Map III.) Nowhere do the underlying formations reappear at the surface after they have once disappeared down dip. Moreover, the most southeasterly exposures of the older formations have at every point been found to show no evidence of having been raised above their normal regional position.

Further evidence of more questionable value is found in the general courses of the streams, most of which flow down dip. The most notable departure from this is afforded by the direction of flow of the Ocmulgee River west of Hazelhurst, where it swings to the east and northeast for about 30 miles. The local prominence in this area of the indurated portion of the Alum Bluff formation may, in large part at least, account for this change of direction of the river course. It is also possible that the headwaters of the present Ocmulgee were captured by the western tributaries of the Oconee-Altamaha River, the character of the Alum Bluff locally aiding this. The waters of the present Ocmulgee may very well have flowed southward through the Withlacoochee or Alapaha rivers before their capture.

Another departure from the normal stream direction is shown by the course of the St. Mary's River. This river in part drains the

Okefenokee Swamp, the natural drainage of which is partly to the Atlantic Ocean on the east and partly to the Gulf of Mexico to the southwest. Because of topographic and structural highs south of the Okefenokee Swamp in Florida there is no drainage directly south. The drainage of the Okefenokee to the east, however, has been interrupted by Trail Ridge, which probably represents an old barrier beach, rather than a structural high. The presence of this barrier would therefore turn the drainage of the Okefenokee to the south until some point (here marked by the eastward direction of the St. Mary's) was reached where the stream could cut across or go around this barrier. East of the present northward-flowing part of the St. Mary's the land is higher and blocks drainage directly east, turning the river northward to the point opposite Folkstone, where its normal direction is resumed.

An examination of the structural map shows that although the St. Mary's River is locally turned from its normal direction by topographic barriers its general course is down regional dip.

Along the major streams throughout at least the inland third of area No. 3 any post-Alum Bluff uplift of only relatively slight magnitude would have brought to the surface the formations below the Alum Bluff. At no place have any such exposures been recognized. Their recognition would, moreover, be easy, for they are limestone, and contrast sharply in lithology with the clays and sands of the Alum Bluff formation.

The presence of flowing wells along the larger streams and over such a large part of the southeastern third of the area constitutes additional evidence against the existence of folds or uplifts of magnitude, younger than the beginning of the deposition of the blue clay of the Alum Bluff formation.

The key horizon selected for determining the regional structure shows only movements subsequent to the deposition of the basal blue clay of the Alum Bluff formation. Where this Alum Bluff clay rests conformably upon older formations older structural conditions would

A. OCALA LIMESTONE, BLUFF OF KITCHAFOONEE CREEK, 7 MILES ABOVE ALBANY.

B. OCALA LIMESTONE IN CUT ON G. S. & F. R. R., 4 MILES NORTH OF GROVANIA, HOUSTON COUNTY.

be shown, but the extent of such conformable relationships is too little known to be of much practical value. There may have been folds antedating the deposition of the blue clays which were planed off and later covered and completely buried by younger beds. No buried structures of this type are known in Georgia, but their presence might possibly be shown by carefully compiled logs of wells drilled in the future.

OIL SEEPS IN GEORGIA

Seeps have been reported from time to time in various parts of the Coastal Plain of Georgia. Usually the supposed oil has been shown to be a film of iron oxide, but in some cases the material has been definitely shown to be genuine crude petroleum. These genuine seeps have been the chief source of interest in the promotion of petroleum investigations.

Seeps of petroleum have been noted 5 to 15 miles south of Augusta, near the Savannah River, near Louisville, Wrightsville, Hawkinsville, Scotland, and Sandersville, and at other places. Among the most noteworthy of these are the seeps near Scotland, Wrightsville, and Hawkinsville. A brief description of each is here given.

Scotland seep.—The oil seepage near Scotland, Telfair County, is on the H. G. Sample farm, about a mile south of the town. The oil occurs as a film on small springs in swampy ground. The surface material belongs to the Alum Bluff formation. This seep has been carefully studied and a report has been published by this Survey. An analysis of the oil is as follows:

Analysis of oil from Scotland oil seep.

Specific gravity at 15° C.			0.8485
Distillate to	150° C	(302° F)	1.4%
Distillate to	150° — 200° C	(302° — 392° F)	3.0%
Distillate	200° — 250° C	(392° — 482° F)	20.0%
Distillate	250° — 300° C	(482° — 572° F)	43.0%
Distillate	300° — 325° C	(572° — 617° F)	15.0%
Residue above	325° C	(617° F)	17.1%

The residue gave the reaction for asphalt.

Wrightsville seep.—The oil seep near Wrightsville, Johnson County, is on the Ed. Spell farm, 4 miles west-northwest of town. The oil occurs as globules and thick films on a small spring issuing from the Glendon formation. This seep yields more oil than any other in the State. Two analyses of the oil are given below.

Analysis of oil sample No. 1

Specific Gravity at 15°		0.870. Baumé 31	
Distillate	50° — 75° C		0.7%
Distillate	125° — 150° C		1.5%
Distillate	150° — 175° C		4.2%
Distillate	175° — 200° C		9.3%
Distillate	200° — 225° C		17.4%
Distillate	225° — 250° C		34.7%
		Total	67.8%

Analysis of oil sample No. 2

Specific gravity at 15°			0.875. Baumé 29½	
Distillate	130° — 150° C	(266° — 302° F)		2 %
Distillate	150° — 200° C	(302° — 392° F)		13½%
Distillate	200° — 250° C	(392° — 482° F)		15 %
Distillate	250° — 300° C	(482° — 572° F)		12½%
Distillate	300° — 350° C	(572° — 662° F)		10 %
Distillate above	350° C	(662° F)		47 %

Paraffin in fraction above 350°

Hawkinsville seep.—Two oil seeps occur near the town of Hawkinsville, Pulaski County. One is on the Fitzroyal farm, 12 miles west of town, and the other is on the R. A. Seales place, ½ mile east of the river at Hawkinsville. At both places the oil occurs as thick globules on springs which issue from swampy ground in the Glendon formation. Both appear genuine. No analysis of the oil from either place is available.

Interpretation.—The interpretation of oil seeps is commonly a difficult task. That they represent the presence of some oil is obvious, but they do not normally give any very good idea as to the quantity and seldom are of value in determining the location of the source.

The seeps of Georgia, so far as the writers have been able to determine, are not associated with any structures favorable for accumulation. Moreover, in no case is there any evidence of faulting or fracturing which would furnish passageways of escape from depth. Also, in practically every case impervious clay beds are near the surface and would tend to stop migration of the oil from depth. In view of these conditions the writers are of the opinion that the seeps do not come from quantity supply at depth.

GENERALIZED STRUCTURE OF THE COASTAL PLAIN OF GEORGIA AND ADJACENT AREAS

Figure 12 shows some general regional structural conditions between Georgia, Florida, and South Carolina. The lines show the general strike of Cenozoic formations and do not represent definite elevations of any particular key horizon. The strike lines throughout Georgia are generalized from the Geologic Map III. Strike lines of the Florida area are generalized and slightly modified from the

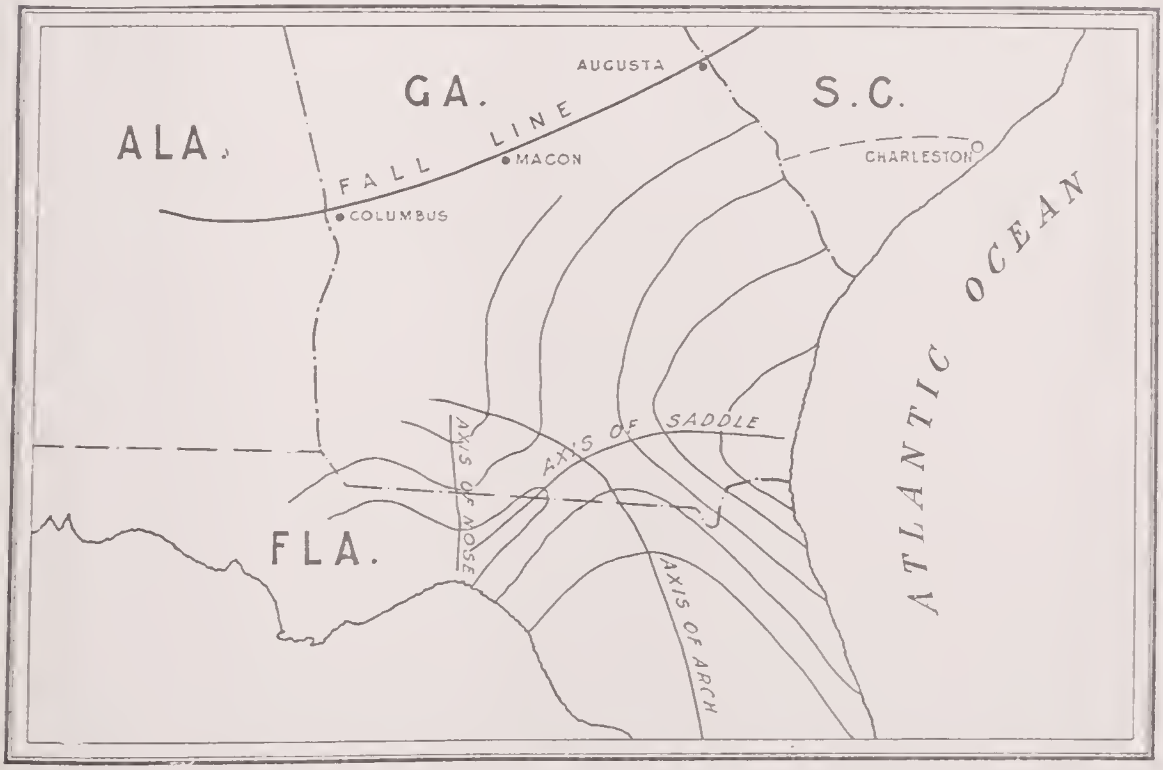


Fig. 11.—Generalized structure of Coastal Plain of Georgia and adjacent areas.

Twelfth Annual Report of the Florida Geological Survey. The single dashed line projected into South Carolina connects the calculated sea level of the top of the Barnwell formation of eastern Georgia with approximate sea level of the top of the Cooper marl of South Carolina. These two horizons are thought to be approximately the same.

CONCLUSIONS ON THE STRUCTURAL CONDITIONS OF THE COASTAL PLAIN OF GEORGIA

The structure of the Coastal Plain of Georgia as a whole appears to be simple. For the most part it is gently monoclinal. Throughout practically the whole of the time which has elapsed since the beginning of Upper Cretaceous time, or earlier, it has not been subjected to intense or violent disturbances, but its movements have apparently been broad, regional oscillations, with recurrent advances and retreats of the seas.

It is, of course, possible that beneath the younger formations, and especially beneath the Miocene strata, folds or faults of magnitude may exist but are now buried, but certainly no evidence of such past movements is available from the present known data.

The structure of the Coastal Plain of Georgia cannot be considered as especially favorable for the accumulation of oil. One or two slight irregularities, as previously described, appear to be present, but the work done has failed to disclose any local structures of much promise.

Throughout practically the whole of area No. 3 the writers feel that with the data that are at present available no more detailed work than has been done is possible, for key horizons of any value are lacking at the surface and any key horizon must be determined from well records. Additional wells with accurate logs may in the future throw added light on the regional structure, but it is extremely doubtful if the local details of the structural conditions of the area as a whole will ever be definitely determined.

Over most of area No. 2 the work done is as detailed as the available data permit, with the results as previously stated. A lack of key beds and much local slumping have restricted the work very largely to a joint interpretation of areal geology and topography. Reliable well logs, on which subsurface key horizons might be accurately located, are too few to be of much real value.

Over a small part of area No. 2, and over a considerable part of area No. 1, more detailed work can be done. However, the work done was sufficiently detailed to disclose any structures of considerable magnitude. Moreover, in a large part of area No. 1 proximity to the old crystalline area north of the Fall line, with the consequent thinness of the sedimentary strata, and the lithologic character of the beds make more detailed work unwarranted.

Different interpretations of the well logs of area No. 3 and of the data in the remainder of the Coastal Plain may somewhat modify the structural conditions shown herein, but the writers believe that such modifications would only slightly affect regional conditions and would fail to throw additional light upon the presence or absence of local structures of magnitude.

PETROLEUM POSSIBILITIES

POSSIBLE SOURCES OF OIL IN THE COASTAL PLAIN

A matter of vital importance in regard to commercial production of oil is the presence, in the formations, of material that could furnish oil in quantity. A summary statement of known conditions relative to a possible source of oil in Georgia is therefore given, as follows:

Cretaceous rocks.—The Cretaceous rocks of Georgia are known to consist, at their outcrops and where encountered in wells, of sand, clay, gravel, some very impure limestone, and some sandy calcareous marls. The lower portion of the Cretaceous wherever seen consists mainly of coarse sand; gravel, and clay of such character that they could not possibly serve as a source of oil. The upper part of the Cretaceous consists generally of light to dark-gray sands, clays, and

marls, both at outcrops and where encountered in wells. Laboratory tests have shown traces of oil from some of the material encountered, but nothing of quantity has been found.

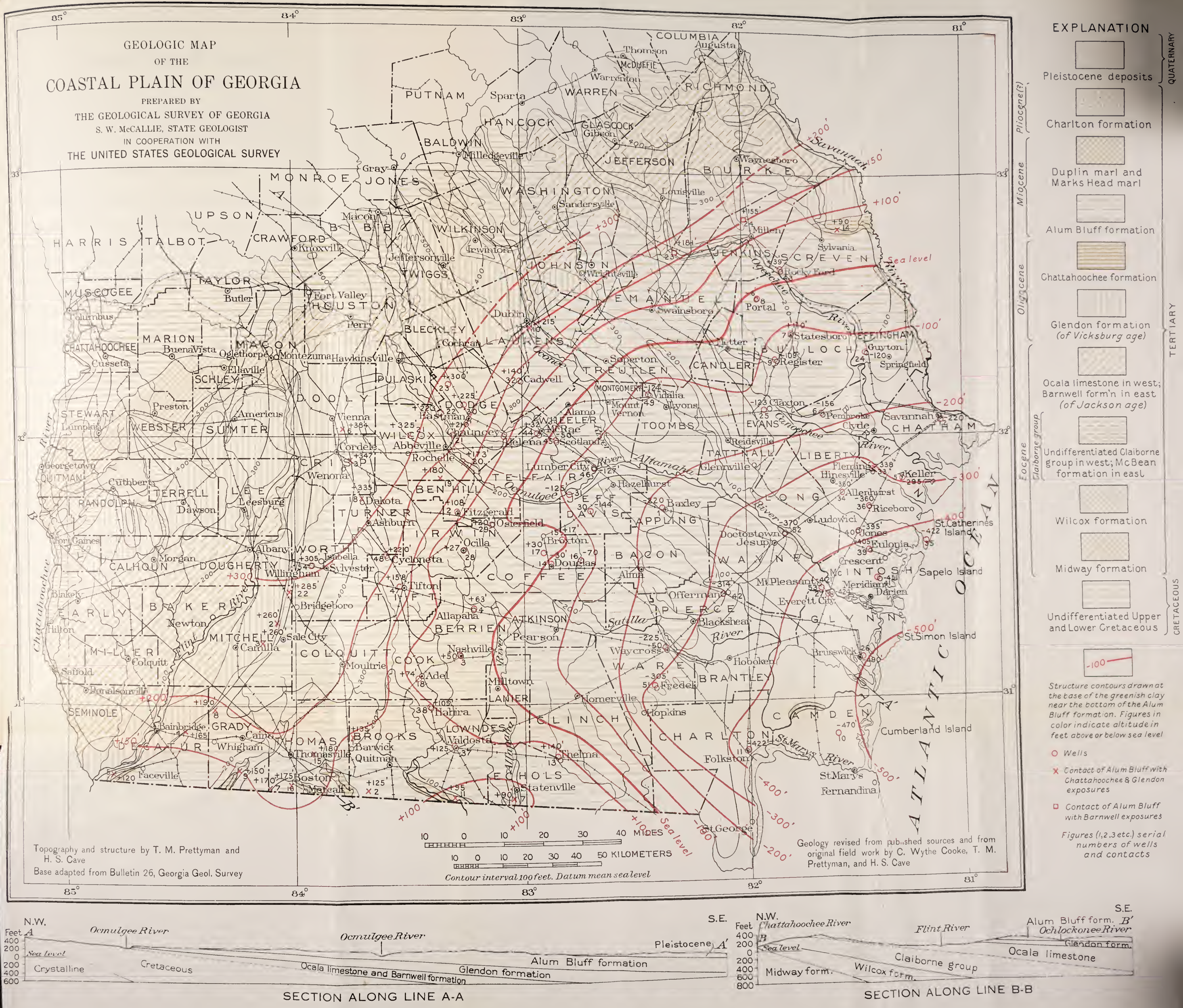
Midway, Wilcox and Claiborne formations.—The rocks of the Midway, Wilcox, and Claiborne formations make up a series of light to dark-colored sands, clays, and marls, with a few lenses of hard gray limestone. Laboratory tests have shown slight traces of oil from well cuttings of some of these formations.

Ocala, Barnwell, Glendon, and Chattahoochee formations.—The rocks of these formations, wherever encountered in wells, consist almost wholly of white to yellow limestones with local flint beds. Numerous tests have failed to show even traces of oil-forming matter in any of these formations.

Alum Bluff formation.—The Alum Bluff formation consists of red to white sands and red to white to bluish and greenish clays. Laboratory tests have shown oil in some of the material.

Summary.—The formations in Georgia, as now known, are not very promising sources of petroleum in commercial quantities. It is of course true that the formations may change lithologically in areas yet untested, and may there be more favorable as an oil source, though from the few fairly deep test wells this is not to be expected. Over all but the inland limits of the Coastal Plain of Georgia no formations older than the lower part of the Ripley have yet been penetrated, and it is therefore possible that the underlying Eutaw or older formations, if present, may be petroliferous. It is also even possible that beneath the Tertiary and Cretaceous in the southeastern part of the Coastal Plain of Georgia petroliferous Paleozoic strata may exist, but this is only a possibility. If such formations were present they would probably be too deep to be reached by the drill, and their value would lie in being a source from which migration of oil to higher horizons could take place.

The presence of oil seeps in the Coastal Plain appears to offer lit-



GEOLOGIC MAP
OF THE
COASTAL PLAIN OF GEORGIA
PREPARED BY
THE GEOLOGICAL SURVEY OF GEORGIA
S. W. McCALLIE, STATE GEOLOGIST
IN COOPERATION WITH
THE UNITED STATES GEOLOGICAL SURVEY
EXPLANATION
Pleistocene deposits
QUATERNARY
Charlton formation
Pliocene(?)
Duplin marl and Marks Head marl
Miocene
Alum Bluff formation
Chattahoochee formation
Oligocene
Glendon formation (of Vicksburg age)
TERTIARY
Ocala limestone in west; Barnwell form'n in east (of Jackson age)
Eocene
Claiborne group
Undifferentiated Claiborne group in west; McBean formation in east
Wilcox formation
Midway formation
Undifferentiated Upper and Lower Cretaceous
CRETACEOUS
-100
Structure contours drawn at the base of the greenish clay near the bottom of the Alum Bluff formation. Figures in color indicate altitude in feet above or below sea level
Wells
Contact of Alum Bluff with Chattahoochee & Glendon exposures
Contact of Alum Bluff with Barnwell exposures
Figures (1,2,3 etc.) serial numbers of wells and contacts
ATLANTIC OCEAN
Topography and structure by T. M. Prettyman and H. S. Cave
Base adapted from Bulletin 26, Georgia Geol. Survey
10 0 10 20 30 40 MILES
10 0 10 20 30 40 50 KILOMETERS
Contour interval 100 feet. Datum mean sea level
Geology revised from published sources and from original field work by C. Wythe Cooke, T. M. Prettyman, and H. S. Cave
N.W.
S.E.
Feet
Ocmulgee River
Sea level
Crystalline
Cretaceous
Ocala limestone and Barnwell formation
Glendon formation
Alum Bluff formation
Pleistocene
SECTION ALONG LINE A-A
Chattahoochee River
Flint River
Alum Bluff form.
Ochlockonee River
Glendon form.
Ocala limestone
Claiborne group
Wilcox form.
Midway form.
SECTION ALONG LINE B-B

tle hope of commercial production, because the data fail to indicate that the oil comes from quantity supply at depth.

The known character of the rocks of the Coastal Plain of Georgia, the noticeable lack of dark shales, organic marls or limestones, or any really petroliferous rocks, would therefore appear not to offer much hope for commercial production of petroleum.

PETROLEUM POSSIBILITIES NORTH OF THE FALL LINE

The portion of Georgia lying north of the Fall line embraces an area of approximately 22,000 square miles, the greater part of which is included in the Piedmont Plateau. Three other physiographic divisions are also represented in the northern portion of Georgia. These are the Appalachian Mountains, the Appalachian Valley, and the Cumberland Plateau. Of these the Appalachian Mountains are of greatest areal extent. The Appalachian Valley and the Cumberland Plateau together are represented in the ten northwest counties of the State.

Piedmont Plateau and the Appalachian Mountains.—Both the Piedmont Plateau region and the Appalachian Mountains in Georgia are composed of very old sedimentary rocks and of igneous rocks, which have repeatedly been subjected to intense folding and squeezing, so that today their structure is very complex, and are all highly crystalline. They are entirely negligible as a possible source of commercial production of petroleum. No rocks of their age and degree of metamorphism have ever produced petroleum in quantity. So highly have the formations of the Piedmont Plateau and the Appalachain Mountains in Georgia been metamorphosed that any possible oil or oil-forming material which the rocks of these areas may ever have contained has long ago passed beyond the hope of recovery as liquid petroleum.

Appalachian Valley and the Cumberland Plateau.—The ten northwest counties of Georgia lie within the areas of the Appalachian Valley and the Cumberland Plateau. The rocks of these regions are

mainly Paleozoic in age, and range from pre-Cambrian, through Cambrian, Ordovician, Silurian, Devonian, Mississippian, and Pennsylvanian.

The Appalachian Valley includes all of the ten northwest counties, with the exception of Dade County and a small part of Walker and Chattooga counties. The rocks are limestones, sandstones, and shales, or their metamorphic equivalents. Though not folded as much as the rocks of the Piedmont Plateau, the formations of the Appalachian Valley area have nevertheless been subjected to intense deformation.

The petroleum possibilities of the Appalachian Valley are very slight, because of two major unfavorable conditions. The first of these is the intense degree to which the formations have been folded. No exact figures on the fixed carbon ratios are available, but the facts that at a few places graphite is present, that the shales have at many places been metamorphosed to slates, that the limestones are in large part either highly crystalline or have been converted to marbles, and that farther west, where the folding is somewhat less intense, the amount of fixed carbon in the coals has passed the 75 per cent ratio, give good evidence that any petroleum or petroleum-forming material that may ever have been present would have been converted into gas and fixed carbon and would no longer be recoverable as liquid oil. It is more probable that small amounts of natural gas might be encountered, though the possibilities of this are of very minor importance.

The second major condition operating against the Appalachian Valley region of Georgia being an area of petroleum production is its structure. Both anticlinal and synclinal folds are present, but so deep has been the erosion in the area that in nearly every case the upper portions of the anticlines have been removed and the rocks that might normally have been regarded as hopeful producers are no longer present, and only very old, non-petroliferous rocks remain. Today the synclines occupy the topographically high areas.

Because of small areal distribution and their degree of metamorphism, these rocks cannot reasonably be expected to contain oil in quantity.

The Cumberland Plateau region of Georgia is embraced in Lookout, Sand and Pigeon mountains. Stratigraphically it is similar to the Appalachain Valley, though the rocks exposed are mainly of Carboniferous age. The region has not been subjected to quite such intense folding as has the Appalachain Valley, but nevertheless the pressures that have been exerted on the rocks have caused the coal in the region to pass beyond the 75 per cent fixed carbon ratio.

Structurally the region is also similar to the Appalachain Valley, though in the Cumberland Plateau area nearly the whole is synclinal, the synclines being the topographically high areas, and the very small valleys are on deeply eroded, sharp anticlines.

The high fixed carbon ratios of the coals of the regions, the synclinal structure of most of the area, the sharpness of the anticlines and their deeply eroded crests, and the crystalline character of most of the rocks are unfavorable to commercial production in the Cumberland Plateau area.

Some of the formations in the Paleozoic area of northwest Georgia are elsewhere oil bearing. This is true of the Chattanooga shale, of Devonian age, the equivalent of which yields oil in Kentucky. But in all productive areas the rocks have been subjected to far less folding and metamorphism than in northwest Georgia.

Summary.—The writers believe the petroleum possibilities of Georgia north of the Fall line are as follows: (1) The Piedmont Plateau and the Appalachian Mountain regions are impossible areas; (2) the Appalachian Valley is a possible area for small oil or gas production, but highly improbable; (3) the Cumberland Plateau region is the most possible for small gas or oil production, but nevertheless is highly improbable.

OIL PROSPECT WELLS NORTH OF THE FALL LINE

Three moderately deep oil-prospect wells have been drilled in Georgia north of the Fall line. One of these was drilled 7 miles south of the town of Madison, the county seat of Morgan County, and the other two were drilled near the city of Rome.

Morgan County Well.—The oil-prospect well of Morgan County was drilled on the Dr. A. O. Willson plantation,7 miles south of Madison. The work was begun in 1908 and continued at intervals for more than three years. The hole was eventually abandoned, at a depth of 1,105 feet. From the beginning the prospect for oil was hopeless, the well being located in the crystalline area of the Piedmont Plateau region.

Rome Petroleum and Iron Company's Well No. 1.—The Rome Petroleum and Iron Company's oil-prospect well No. 1 was located about 4½ miles northwest of Rome. The drilling was done during 1902 and 1903, and a depth of about 1200 feet was attained. The well was commenced in the Floyd shale, of Mississippian age. The drilling was probably stopped in the lower part of the Rockwood formation, of Silurian age. The formations thus encountered were Floyd shale and Fort Payne chert (Mississippian) and the Rockwood (Silurian) formation. It is doubtful if any Chattanooga black shale (Devonian) was encountered in the hole. No production of oil or gas was obtained.

Rome Petroleum and Iron Company's Well No. 2.—This second test well was located about 8 miles west of Rome. It was drilled during 1902 and 1903, and attained a depth of 1,850 feet. The well was apparently begun in the Floyd shale, and penetrated the Fort Payne chert, the Rockwood formation, and possibly stopped in the Chickamauga limestone, of Ordovician age. No production of oil or gas was obtained.

The two wells in the Rome area were located in possible but highly improbable areas, due to the degree of metamorphism of the formations and to their general lithologic character.

GENERAL CONCLUSIONS ON PETROLEUM POSSIBILITIES OF GEORGIA

Coastal Plain.—A review of the data relative to the Coastal Plain of Georgia, as set forth in the foregoing pages of this bulletin, shows a lack of any structures that would be expected to cause accumulation of petroleum in commercial quantities. The lithology of the rocks likewise offers little prospect of petroliferous horizons. Buried structures and petroliferous formations may exist, but from all the available data the writers are not very hopeful of commercial production of petroleum in the Coastal Plain of Georgia, and feel that any considerable degree of optimism is unwarranted.

In view of the fact that prospecting will probably be done in Georgia in the future, the writers feel that regionally the areas described below offer relatively the most hope for drilling. The structural map (Map III.) shows that slight structural highs exist, and there is the possibility that these structures may increase in magnitude with depth. The most hopeful are as follows, in order of importance: (1) Along the slight structural arch shown in the Thomasville area; (2) along the apparent crest extending from Camilla through Valdosta and thence east, southeast through the area between Statenville and Thelma; (3) the area roughly embraced by a line drawn through the towns of Douglas, Broxton, Osierfield, and Ocilla; (4) along the gentle arching shown by a nose with axis approximately along a straight line extending from Claxton through Metter and passing about 12 miles east of Swainsboro.

North of the Fall line.—As previously stated, that portion of Georgia lying north of the Fall line offers scant hope for commercial production of petroleum. The character of the rocks and their degree of metamorphism in the regions of the Piedmont Plateau and Appalachian Mountains make these areas impossible ones. The Appalachian Valley and the Cumberland Plateau areas offer more hope, although the general lithologic character of the rocks, their high de-

gree of metamorphism, and the deep erosion of the regions make these portions of the State possible, but highly improbable, areas of commercial production.

APPENDIX A

SOME GENERAL CONSIDERATIONS RELATIVE TO THE PRODUCTION OF OIL AND GAS

Oil leases.—The right to drill for oil and gas on any property is usually acquired by an oil and gas lease, at a specified price per acre. In addition to this lease price the lessee usually pays a smaller amount per acre every year during which the lease is operative. This additional payment is known as rental. A small fraction, commonly one eighth, of any oil and gas produced goes to the owner of the land. This is called royalty. Leases are usually for a specified term of years the lessee generally agreeing to begin drilling within a few months after the signing of the lease and continue drilling with due diligence. This guarantee is usually secured by forfeit money placed in some bank. In some instances the land is purchased in fee simple.

Cost of drilling oil wells.—The cost of drilling a well varies within the very wide limits of a few hundred dollars to $100,000 or more. These wide limits are generally due to variation in one or more of the following governing factors: depth of well, nature of rocks encountered, cost of casing, cost of labor, proximity to transportation and to drilling services and equipment, and numerous drilling difficulties encountered.

Spacing of wells.—The proper economic spacing of oil wells should be such as to give the maximum total recovery from a given area with the least number of wells. Numerous geologic factors, such as continuous porosity of the producing sand, viscosity of the oil, etc., enter into the problem, calling for different spacing in different areas. The average proper distance between wells is probably about 600 feet. It is unfortunate, but true, that in many highly productive areas the wells are too close together.

Petroleum Geologists.—The location of oil and gas tests should be based on the principles that govern the origin and accumulation of petroleum and natural gas. To correctly interpret these geological data is the work of the petroleum geologist, and not the work of a driller or a layman. In most cases a driller is not a trained geologist, and is therefore not fitted to determine geological conditions, except perhaps in some particular area with which he is very familiar, by reason of having done much drilling there.

All persons who are interested in the possible development of any area, with the view to locating oil or gas, are therefore strongly advised to procure the services of a competent petroleum geologist. The names of competent and reliable men can normally be obtained from the United States Geological Survey, at Washington, D. C., or from any State geological survey, or from universities that maintain departments of geology.

Like every other profession, petroleum geology has its "quacks," and these should be guarded against. Very commonly these "quacks" receive local reputations as experts, due very often to their being so called by local newspapers.

The maintainance of geological departments by most of the large oil companies should be ample proof of the value of the services of a petroleum geologist.

Laws governing drilling for oil.—Each oil producing State has its own laws governing the drilling for oil and gas. These laws are primarily designed for the protection of rights, the conservation of natural resources, and to secure industrial economy. Some of the main points covered by these laws are: The spacing of wells, the proper handling of water encountered, to prevent flooding of producing sands, and the wasteful escape of gas and oil.

The following bill which passed the Georgia Senate, August 6, 1920, but failed to pass the House on account of the congestion of business the last days of the session, is a modern and up to date bill, and will probably be enacted by the present legislature:

PROPOSED BILL GOVERNING THE CONSTRUCTION OF OIL AND GAS WELLS, ETC., IN GEORGIA

Section 1. *Be it enacted by the General Assembly of the state of Georgia and it is enacted by the same,* That before commencing the work of drilling an oil or gas well in this state the owner or operator of such well must file with the State Geologist a written notice of intention to commence drilling. Such notice shall also contain the following information: (1) Statement of location and elevation above sea level of the floor of the proposed derrick and drill rig; (2) the number or other designation by which such well shall be known, which number or designation shall not be changed after filing the notice provided for in this section without the written consent of the State Geologist being obtained thereof; (3) the owner's or operator's estimate of the depth of the point at which water will be shut off, together with the method by which such shut off is intended to be made and the size and weight of casing to be used; (4) the owner's or operator's estimate of the depth at which oil or gas producing sand or formation will be encountered.

After the completion of any well the provisions of this section shall also apply, as far as may be, to the deepening or redrilling of any well or any operation involving the plugging of any well or any operations permanently altering in any manner the casing of any well; and provided further, that the number or designation by which any well heretofore drilled has been known shall not be changed without first obtaining a written consent of the State Geologist.

Section 2. *Be it further enacted,* it shall be the duty of the owner or operator of any well referred to in this act, to keep a careful and accurate log of the drilling of such well, such log to show the character and depth of the formation passed through or encountered in the drilling of such well, and particularly to show the location and depth of the water bearing strata, together with the character of the water encountered from time to time (so far ascertained) and to show at what point such water was shut off, if at all, and if not, to

so state in such log, and show completely the amounts, kinds, and size of casing used, and show the depth and character of the same, and whether all water overlying and underlying such oil bearing strata was successfully and permanently shut off so as to prevent the percolation or penetration into such oil bearing strata; such log with samples of well borings taken at stated intervals of not more than 10 feet unless waived by the State Geologist and shall be kept in the local office of the owner or operator, and shall be subject, during business hours, to the inspection of the State Geologist or any of his assistants, except in the case of a prospect well which shall include all wells in unproven territories. Upon the completion of any well, or upon the suspension of operation upon any well, for a period of six months if it be a prospect well, or for 30 days, if it be in proven territory, a copy of said log shall be filed within 10 days after such completion, or after the expiration of said 30-day periods, with the State Geologist, and a like copy shall be filed upon the completion of any additional work in the deepening of any such well.

Section 3. *Be it further enacted*, that the distance of wells shall not be closer to property lines than 200 feet while the regulated distance of wells on individual properties shall be so spaced as to extract the oil at the least possible cost, but no well shall be nearer a producing or drilling well than 200 feet.

Section 4. *Be it further enacted*, That it shall be unlawful for any owner or operator having possession or control of any natural gas or oil well, to allow or permit the flow of gas or oil from any such well, to escape into the open air, without being confined within such well or proper pipes, or other safe receptacle, for a period longer than two (2) days, next after gas or oil shall have been struck in such well, and thereafter all such gas or oil shall be safely and securely confined in such wells, pipes or other safe and proper receptacles; provided that this law shall not apply to any well that is being operated for the production of oil and in which the oil produced has a higher salable value in the field than has the gas so lost.

Section 5. *Be it further enacted,* That whenever any well shall have been sunk for the purpose of obtaining natural gas or oil or exploring for the same, and shall be abandoned or cease to be operated for utilizing the flow or gas or oil therefrom it shall be the duty of any persons, firm or corporation having the custody or control of such well at the time of such abandonment or cessation of use, and also of the owner or owners of the land wherein such well is situated, to properly and securely stop and plug the same as follows: If such well has not been "shot" there shall be placed in the bottom of the hole thereof a plug of well-seasoned pine wood, the diameter of which shall be within one-half inch as great as the hole of such well, to extend at least three feet above the salt water level, where salt water has been struck, such plug shall extend at least three feet from the bottom of the well. In both cases such wooden plugs shall be thoroughly rammed down and made tight by the use of drilling tools. After such ramming and tightening the hole of such well shall be filled on top of such plug with finely broken stone or sand, which shall be well rammed at a point at least four feet above the gas or oil bearing rock; on top of this stone or sand there shall be placed another wooden plug at least five feet long with diameter as aforesaid, which shall be thoroughly rammed and tightened. In case such well has been "shot" the bottom of the hole thereof shall be filled with a proper and sufficient mixture of sand, stone and dry cement, so as to form a concrete up to a point at least eight feet above the top of the gas or oil bearing rock or rocks, and on top of this filling shall be placed a wooden plug at least six feet long, with diameter as aforesaid. The casing from the well shall then be pulled or withdrawn therefrom. and immediately thereafter a cast iron ball, eight inches in diameter, shall be dropped in the well, and securely rammed into the shale by the driller or owner of the well, after which not less than one cubic yard of sand pumping or drilling taken from the well shall be put on top of said iron ball.

Section 6. *Be it further enacted,* That the right of eminent domain may exist and be exercised, for public use, by and in behalf

of any person, firm or corporation for the construction and operation of pipe lines for the transportation of oil or gas, where in the opinion of the State Geologist there is a sufficient supply of oil or gas to warrant the construction of pipe lines, and subject to existing laws and rules and regulations to be provided by the Railroad Commission of The State of Georgia whereby methods of construction shall be fixed and rates for transportation of oil and gas shall be established.

Section 7. *Be it further enacted,* That the legal form of oil and gas lease for this state shall be as follows:

AGREEMENT, Made and entered into the..........day of...... ....19....by and between.......................... of .... hereinafter called lessor (whether one or more) and................ ....of .... hereinafter called lessee.

Witnesseth: That the said lessor, for and in consideration of ....Dollars cash in hand and paid, receipt of which is hereby acknowledged, and of the covenants and agreements hereunder contained on the part of lessee to be paid, kept and performed, ha..............granted, demised, leased and let and by these presents do..............grant, demise, lease and let unto the said lessee for the sole and only purpose of mining and operating for oil and gas and of laying of pipe-lines, and of building tanks, powers, stations and structures thereon to produce, save and take care of said products, all that certain tract of land situated in the county of.............................State of Georgia, described as follows, to-wit:

....

....

..............................and containing............acres, more or less. . . . .

It is agreed that this lease shall remain in force for a term of.. ....years from this date, and as long thereafter as oil

or gas, or either of them, is produced from said land by lessee.

In consideration of the premises the said lessee covenants and agrees:

1st. To deliver to the credit of lessor, free of cost, in the pipe line to which they may connect their wells, the equal one-eighth part of all oil produced and saved from the leased premises.

2nd. To pay the lessor.......................... dollars each year, in advance, for the gas from each well where gas only is found, while the same is being used off the premises, and lessor to have gas free of cost from any such well for all stoves and all inside lights in the principle dwelling houses on said land during the same time by making................ own connection with the well at.................. own risk or expense.

3rd. To pay lessor for gas produced from any oil well and used off the premises at the rate of........................ Dollars per year, for the time during which such gas shall be used, said payments to be made each three months in advance.

If no well be commenced on said land on or before the.......... day of.................... 19.... this lease shall terminate as to both parties, unless the lessee on or before that date shall pay or tender to the lessor, or to the lessor's credit in the............... .... Bank at.............................. or its successors, which shall continue as the depository, regardless of changes in the ownership of said land, the sum of................. ...... Dollars, which shall operate as rental and cover the privilege of deferring the commencement of a well for.................. months from said date. In like manner and upon like payments or tenders the commencement of a well may be further deferred for like periods in the same number of months successively. And it is understood and agreed that the consideration first recited herein, the down payment, covers not only the privilege granted to the date when said first rental is payable as aforesaid, but also the lessee's option of extending that period as aforesaid, and any and all other rights conferred.

Should the first well drilled on the above described land be a dry hole, then, and in that event, if a second well is not commenced on said land within twelve months from the expiration of the last rental period for which rental has been paid, this lease shall terminate as to both parties, unless the lessee on or before the expiration of said twelve months shall resume the payment of rentals in the same amount and in the same manner as hereinbefore provided. And it is agreed that upon the resumption of the payment of rentals, as above provided, that the last preceding paragraph hereof governing the payment of rentals and the effect thereof, shall continue in force just as though there had been no interruption in the rental payments.

If said lessor owns a less interest in the above described land than the entire and undivided fee simple estate therein, then the royalties and rentals herein provided for shall be paid the lessor only in the proportion which....................interest bears to the whole and undivided fee.

Lessee shall have the right to use, free of cost, gas, oil and water produced on said land for all operations thereon except water from wells of lessor.

When requested by lessor, lessee shall bury their pipe line below plow depth.

No well shall be drilled nearer than 200 feet to the house or barn now on said premises without the written consent of lessor.

Lessee shall pay for damages caused by all operations to growing crops on said land.

Lessee shall have the right at any time to remove all machinery and fixtures on said premises, including the right to draw and remove casing.

If the estate of either party hereto is assigned—and the privilege of assigning in whole or in part is expressly allowed—the covenants hereof shall extend to their heirs, executors, administrators, successors or assigns, but no change in the ownership of the land or assign-

ment or rentals or royalties shall be binding on the lessee until after the lessee has been furnished with a written transfer or assignment or a true copy thereof; and it is hereby agreed that in the event this lease shall be assigned as to a part or as to parts of the above described lands and the assignee or assignees of such part or parts shall fail or make default in the payment of the proportionate part of the rentals due from him or them, such default shall not operate to defeat or affect this lease in so far as it covers a part or parts of said lands upon which the said lessee or any assignee thereof shall make due payment of said rental.

Lessor hereby warrants and agrees to defend the title to the lands herein described, and agrees that the lessee shall have the right at any time to redeem for lessor, by payment, any mortgages, taxes or other liens on the above described lands, in the event of default of payment by lessor, and be subrogated to the rights of the holder hereof.

WITNESS..................hand..................seal, this the ....day of..........................19....

Witnesses:

....	....
....	....
....	....

Section 8. *Be it further enacted,* That any owner or operator of oil or gas wells in the State of Georgia violating the provisions of this Act, shall be guilty of a misdemeanor, and upon conviction thereof shall be fined any sum not exceeding five hundred dollars ($500.00) or shall be imprisoned for a period not exceeding three months, in the discretion of the court.

Section 9. *Be it further enacted,* That all laws and parts of laws in conflict with this act are hereby repealed.

A. H. G. SAMPLE'S OIL SEEP NO. 1, SCOTLAND, TELFAIR COUNTY.

B. H. G. SAMPLE'S OIL SEEP NO. 2, SCOTLAND, TELFAIR COUNTY.

APPENDIX B.

ALTITUDES IN THE COASTAL PLAIN OF GEORGIA

Throughout the Coastal Plain of Georgia numerous elevations have been established at various points by the United States Geological Survey, United States Army Engineers, and the engineering departments of various railroads. Using these elevations as a base the Geological Survey of Georgia has established the elevations of numerous other points by repeated checkings with aneroid barometers or by the joint use of a barograph and aneroid barometers. The limit of error of the elevations thus established is probably less than 10 feet.

ELEVATIONS IN GEORGIA COASTAL PLAIN.

TOWN	Authority	Elevation, Feet
Aaron	U. S. G. S.	260
Abbeville (Court House)	Aneroid	255
" low water	U. S. A. Eng.	169.33
Achord	U. S. G. S.	274
Acree, Dougherty Co.	A. C. L.	205
Adams Park	U. S. G. S.	259
Adel	G. S. & F.	246
Adrain, Emanuel Co.	Rough Est.	290
Ailey	Aneroid	250
Alamo	"	245
Albany, Flint River Level	A. C. L.	127
" bridge	Aneroid	175
Allapaha	A. C. L.	293
Alexander	U. S. G. S.	283
Alexanderville	A. C. L.	153
Allenhurst	U. S. G. S.	60
Allentown	M. D. & S.	411?
Alma	Aneroid	195
Ambrose, Coffee Co.	Aneroid	280
Americus	C. of G.	360
Andersonville	"	394
Anguilla	U. S. G. S.	10
Appling	"	263
Arabi	G. S. & F.	460
Arcola	U. S. G. S.	125
Argyle	A. C. L.	161
Arlington	Rough Est.	275
Armena	S. A. L.	275

Altitudes in coastal plain—continued.

TOWN	Authority	Elevation, Feet
Ashburn	G. S. & F.	450
Atkinson	U. S. G. S.	68
Attapulgus	G. F. & A.	175
Augusta, low water	U. S. G. S.	109
" Union Sta.	City Eng.	143
Autreyville	Aneroid	315
Avondale	G. S. & F.	360
Baconton	A. C. L.	160
Bainbridge	"	110
" water level	G. F. & A.	68
Bankston	Sou. Ry.	359
Bartow	C. of G.	237
Barwick	Aneroid	235
Bascom	U. S. G. S.	118
Bath, Richmond Co.	Rough Est.	400
Baxley	U. S. G. S.	206
Baxter	"	117
Beachton	Aneroid	260
Belair	Ga. R. R.	295
Bellville	U. S. G. S.	185
Berzelia	Ga. R. R.	488
Blackshear	A. C. L.	106
Bladen	U. S. G. S.	16
Blakely	Rough Est.	275
Blanford	U. S. G. S.	79
Blanton	G. S. & F.	172
Bloomingdale	C. of Ga.	24
Bonaire	G. S. & F.	354
Boston	A C. L.	194
Bostwick (Paschal)	C. of Ga.	669
Boulogne, Fla.	U. S. G. S.	59
Box Springs	"	364
Braganza	A. C. L.	144
Brentwood	U. S. G. S.	167
Brewer (Tusculum P. O.)	"	122
Broadhurst	"	56
Brookfield	A. C. L.	332
Brooklet	U. S. G. S.	159
Brooklyn	S. A. L.	691
Broxton	Aneroid	265
Brinson	A. C. L.	104
Browntown	U. S. G. S.	70
Brunswick	Sou. Ry.	13
" City Hall	U. S. G. S.	11

TOWN	Authority	Elevation, Feet
Buena Vista	Rough Est.	590
Bullards	U. S. G. S.	259
Burroughs	A. C. L.	19
Bushnell	Rough Est.	260
Butler	C. of Ga.	650
Byromville	A. B. & A.	365?
Byron	C. of Ga.	515
Cadwell	Aneroid	345
Cairo	A. C. L.	237
Camak	Ga. R. R.	578
Cameron	U. S. G. S.	102
Camilla	A. C. L.	167
Canoochee	S. & S.	372
Carling	U. S. G. S.	403
Carrs Station	"	500
Cecil	G. S. & F.	250
Ceylon	U. S. G. S.	18
Chalker	Aneroid	330
Chauney	U. S. G. S.	300
Chula	G. S. & F.	395
Claxton	U. S. G. S.	187
Clifton	C. of Ga.	22
Climax	A. C. L.	277
Clyo	U. S. G. S.	72
Cochran	"	342
Colebrook, Effingham Co.	Brinson R. R.	65
Coleman	C. of Ga.	391
Colesburg	U. S. G. S.	20
Coley	Sou. Ry.	303
Collins	S. A. L.	238
Colon	G. S. & F.	137
Colquitt	Rough Est.	175
Columbus	U. S. G. S.	250
" river level	"	200
Cordele	G. S. & F.	336
Cox	U. S. G. S.	17
Cresent	Rough Est.	18
Cox, Sou. Ry.	U. S. G. S.	287
Culverton	Ga. R. R.	549
Cusetta	U. S. G. S.	540
Cushingville	C. of Ga.	153
Cuthbert	C. of Ga.	446
Cutler	G. S. & F.	78
Cuyler	S. A. L.	37?
Cycloneta	G. S. & F.	410

TOWN	Authority	Elevation, Feet
Daisy	U. S. G. S.	177
Dakota	G. S. & F.	410
Dales Mill	A. C. L.	136
Darien	Rough Est.	15
Dames Ferry	U. S. G. S.	346
Dasher	G. S. & F.	185
Davis	A. C. L.	238
Davisboro	C. of Ga.	302
Dawson	"	352
Days Gap	Sou. Ry.	333
Dearing	Ga. R. R.	464
Denmark	U. S. G. S.	182
Devereux	"	577
Dewitt	Butts Map	175
Dixie	A. C .L.	130
Dock Junction	U. S. G. S.	25
Doctortown	U. S. G. S. (B. M.)	63
" station	U. S. A. Eng.	74
" low-water level	U. S. A. Eng.	28.72
Doerun	Aneroid	425
Doles	"	260
Donald	U. S. G. S.	83
Donaldsonville	A. C. L.	139
Dooling	A. B. & A.	270
Douglas	Aneroid	255
Doublerun	A. B. & A.	363?
Dover	U. S. G. S.	103
Dry Branch	M. D. & S.	368?
Dublin, river level	U. S. A. Eng.	160.6
" bridge	Hand level	201
Dubois	Sou. Ry.	391
Dudley	M. D. & S.	325?
Dunbarton	U. S. G. S.	251
Dupont	A. C. L.	180
East Albany	A. C. L.	186
Eastman	U. S. G. S.	357
Eden	C. of Ga.	34
Egypt	U. S. G. S.	133
Eldorado	G S & F	340
Elko	"	443
Ellabelle	S. A. L.	93?
Ellaville	Aneroid	555
Emmalane	U. S. G. S.	207
Empire	"	382
Enigma	A. C. L.	309
Esquiline	U. S. G. S.	300

Altitudes in coastal plain—continued.

TOWN	Authority	Elevation, Feet
Eufaula, Ala.	C. of Ga.	211?
Everett City	U. S. G. S.	16
Everett Station, Crawford Co.	C. of Ga.	362
Everett Station, Flint River R. R. Br.	"	337
Exeter	A. C. L.	94
Exley	S. A. L.	63
Faceville	A. C. L.	296
Fargo	G. S. & F.	116
Fendig	U. S. G. S.	84
Fitzgerald	Aneroid	350
Fitzpatrick	M. D. & S.	541
Fleming	A. C. L.	22
Flint	"	168
Folkston	U. S. G. S.	81
Forest, Clinch Co.	A. C. L.	166
Fort Gaines	Aneroid	215
" " low water	"	91
" "	C. of Ga.	163
Fort Mudge	A. C. L.	134
Fort Valley	C. of Ga.	522
Fowlstown	A. C. L.	289
Gallemore (Willis P. O.)	M. D. & S.	394?
Gardi	U. S. G. S.	62
Garfield	G. & F.	287
Geneva (Station)	U. S. G. S.	581
Georgetown low water	C. of Ga.	189
Gillionville	Aneroid	245
Girard	U. S. G. S.	241
Glencoe	"	20
Glenmore	A. C. L.	151
Glenville	U. S. G. S.	175
Glenwood	Aneroid	195
Godwinville	U. S. G. S.	312
Gordon	C. of Ga.	348
Gordon, Ala.	A. C. L.	160
Gough	U. S. G. S.	394
Graham	Sou. Ry.	240
Grangerville	U. S. G. S.	80
Graves	C. of Ga.	350
Grays	A. C. L.	232
Greens Cut	U. S. G. S.	276
Greenville	"	447
Gresston	"	401

Altitudes in coastal plain—continued.

TOWN	Authority	Elevation, Feet
Grimshaw	U. S. G. S.	180
Griswold	C. of Ga.	447
Grovania	G. S. & F.	444
Groveland	U. S. G. S.	158
Grovetown	Ga. R. R.	495
Guyton	U. S. G. S.	80-90
Hagan	"	190
Hahira	G. S. & F.	230
Halcyondale	U. S. G. S.	113
Halloca	U. S. G. S.	323
Hardaway	A. C. L.	183
Hardeeville, S. C.	"	21
Harlem	Ga. R. R.	548
Harrison, Washington Co.	Aneroid	400
Hatcher	C. of Ga.	289?
Hatley	A. & B. Rwy.	305
Hawkinsville	Weather Bureau	235
" low-water level	U. S. A. Eng.	200.2
Haylow	G. S. & F.	167
Hazelhurst	U. S. G. S.	256
Helena	"	247
Hephizabah	Weather Bureau	402
Herndon	C. of Ga.	179
Hickox	U. S. G. S.	65
Higgston	Aneroid	298
High Point	U. S. G. S.	15
Hilltonia	"	215
Hinesville	"	78
Homeland	"	88
Homerville	A. C. L.	176
Hortense	U. S. G. S.	56
Howard	C. of Ga.	666?
Howell, Echols Co.	G. S. & F.	169
Hubert	U. S. G. S.	103
Idlewood	"	294
Inaha	G. S. & F.	415
Irwinton	U. S. G. S.	448
Isabella (Sylvester)	A. C. L.	370
Ivanhoe	U. S. G. S.	93
Jamaica	A. C. L.	21
Jasper, Fla.	A. C. L.	152
Jakin	A. C. L.	140
Jeffersonville	M. D. & S.	526

Altitudes in coastal plain—continued.

TOWN	Authority	Elevation, Feet
Jennie	U. S. G. S.	185
Jennings. Fla.	G. S. & F.	150
Jerusalem	U. S. G. S.	17
Jesup	U. S. G. S.	100
Johnson	C. of G.	254
Johnsonville, Jeff Davis Co.	Sou. Ry.	240
Johnston	A. C. L.	71
Juniper Sta.	U. S. G. S.	422
Kathleen	G. S. & F.	330
Keysville	U S. G. S.	280
Kibbee	Aneroid	322
Kildare, Effingham Co.	U. S. G. S.	129
Kimbrough	U. S. G. S.	558
Kingsland	U. S. G. S.	34
Kirkland	A. C. L.	236
Kittrels	Aneroid	350
Knoxville	J. E. Thomas	640
Lake Park	G. S. & F.	160
Lambert	U. S. G. S.	92
Lanier	U. S. G. S.	70
Lawton	U. S. G. S.	219
Leary	D. L. Wardroper	210
Lee Pope	Aneroid	522
Leesburg	Aneroid	282
Lela	A. C. L.	146
Leliaton	Aneroid	245
Leland	U. S. G. S.	141
Lenox	G. S. & F.	300
Letford	U. S. G. S.	62
Lewiston	C. of Ga.	385
Lida	U. S. G. S.	95
Lily	A. B. & A.	364
Lincolnton	U. S. G. S.	500
Longstreet	"	302
Long Pond, Hancock Co.	"	66
Lorenzo	"	100
Louisville	"	337
Ludowici	A. C. L.	71
Lulaton	U. S. G. S.	82
Lumber City	U. S. G. S.	146
" " low-water level	U. S. A. Eng.	84.7
Lumpkin, station	Aneroid	515
Lynn	U. S. G. S.	173
Lyons	S. A. L.	254

Altitudes in coastal plain—continued.

TOWN	Authority	Elevation, Feet
McBean Station	U. S. G. S.	138
McClenny, Fla.	S. A. L.	125
McCormick	U. S. G. S.	535
McDonald	A. C. L.	167
McGregor	Aneroid	328
McGriff	U. S. G. S.	259
McIntosh	U. S. G. S.	20
McIntyre	"	270
McKinnon	"	65
McRae	"	230
Macon, Union Station	G. S. & F.	334
" near Sou. Ry. Sta.	U. S. G. S.	311
" low-water level	U. S. A. Eng.	279.02
Macon Junction	C. of Ga.	350
Manassas	S. A. L.	217
Manson	U. S. G. S.	60
Marshallville	C. of Ga.	500
Marlow	U. S. G. S.	72
Mattox	U. S. G. S.	70
Matthews	"	394
Mayday	G. S. & F.	140
Mayfield	Ga. R. R.	417.5
Meigs	A. C. L.	341
Meinhard	S. A. L.	19
Meldrim	C. of Ga.	28
Melrose	G. S. & F.	154
Mendes	U. S. G. S.	179
Metcalf	A. C. L.	170
Midville	C. of Ga.	186
Milan	Aneroid	310
Milledgeville	U. S. G. S.	326
" low-water level	U. S. A. Eng.	241.29
Millen	U. S. G. S.	160
Millhaven	"	110
Millwood	A. C. L.	160
Mineola	G. S. & F.	220
Misler	U. S. G. S.	293
Modoc	U. S. G. S.	406
Moniac	"	117
Monteith	A. C. L.	16
Montezuma	C. of Ga.	300
Montezuma, Flint River low-water	Aneroid	265
Montrose	M. D. & S.	391 ?
Morgan	Weather Bureau	337

Altitudes in coastal plain—continued.

TOWN	Authority	Elevation, Feet
Morris	C. of Ga.	242
Mount Pleasant	U. S. G. S.	55
Mount Vernon	Highway Eng.	230
Moultrie	Aneroid	340
Munnerlyn	U. S. G. S.	268
Miscogee	U. S. G. S.	245
Myers, Effingham Co.	S. A. L.	45
Nahunta	U. S. G. S.	66
Nashville	Aneroid	265
Naylor	A. C. L.	192
Needmore	U. S. G. S.	67
Nesbitt	"	145
Newington	"	143
Newton, water level	Aneroid	95
Newell	U. S. G. S.	77
Nicholls	Aneroid	195
Norman Park	"	380
Norwood	Ga. R. R.	588
Ocilla	Aneroid	327
Ochillee	U. S. G. S.	273
Ochlocknee	A. C. L.	263
Ochwalkee, low-water Oconee R.	U. S. A. Eng.	114.4
Oconee	C. of Ga.	223
Odum	U. S. G. S.	155
Offerman	A C. L.	106
Ogeechee	U. S. G. S.	180
Oglethorpe	C. of Ga.	299
Ohoopee	S. A. L.	187
Okmulgee	Sou. Ry.	124
Old Sardis	U. S. G. S.	257
Oliver	"	108
Olney	"	63
Omaha, station	Rough Est.	240
Orange Bluff	U. S. G. S.	10
Osierfiled	Aneroid	350
Ousley	A. C. L.	148
Paramore Hill, station	U. S. G. S.	235
Parkwood	"	25
Parksville	"	352
Parrott	S. A. L.	482
Paschal (Bostwick)	C. of Ga.	669
Patterson	A. C. L.	104
Pearson	U. S. G. S.	203
Pelham	"	355

Altitudes in coastal plain—continued.

TOWN	Authority	Elevation, Feet
Pembroke	U S. G. S.	94
Pendarvis	"	85
Pennick	"	18
Perkins	"	233
Perry	Aneroid	355
Peterson	U. S. G. S.	73
Pikes Peak, station	M. D. & S.	534
Pinegrove	U. S. G. S.	229
Pinehurst	G. S. & F.	390
Pineora	U. S. G. S.	75
Pine View	Aneroid	288
Piscola, Brooks Co.	Weather Bureau	190
Plains	Aneroid	490
Plum Branch	U. S. G. S.	462
Pooler	C. of Ga.	23
Portal	U. S. G. S.	294
Poulan	A. C. L.	345
Powersville	C. of Ga.	385
Prentiss	Sou. Ry.	207
Pretoria	U. S. G. S.	220
Pulaski	"	220
Quitman	A. C. L.	173
Racepond	A. C. L.	148
Rahns	U. S. G. S.	73
Raybon	"	49
Rebecca	A. B. & A.	373?
Recovery	A. C. L.	189
Register	U. S. G. S.	171
Reid	"	272
Reidsville	Estimate	200
Renfroes	S. A. L.	601?
Reynolds	C. of Ga.	433
Riceboro	Rough Est.	15
Rich Hill, Crest	Aneroid	707
Richland	S. A. L.	600
Richwood	G. S. & F.	358
Rincon	S. A. L.	75
River Junction, Fla.	L. & N.	84
Roberta	Aneroid	487
Roberts Station	Ga. R. R.	557
Rochelle	Aneroid	369
Rocky Ford	U. S. G. S.	124
Roderick	"	79
Rogers	C. of Ga.	159

Altitudes in coastal plain—continued.

TOWN	Authority	Elevation, Feet
Saffold	A. C. L.	105
" level Chattahoochee R.	Rough Est.	65
St. Clair	U. S. G. S.	387
St. George	"	78
St. Marys	"	15
Sales City	Aneroid	397
Sandersville	Aneroid	445
Sap Still	U. S. G. S.	18
Sardis	U. S. G. S.	239
Satilla	A. C. L.	96
Satilla, river level Little Satilla	"	71
Savannah	"	21
Scarboro	U. S. G. S.	160
Schlatterville	A. C. L.	133
Scotland	U. S. G. S.	142
Screven	A. C. L.	124
Sebastopol	C. of Ga.	225
Shawnee	U S. G. S.	124
Sheba	U S. G. S.	580
Shell Bluff (P. O.)	"	301
Shell Bluff Landing, low water	U. S. A. Eng.	87
" " " highest point	"	237
Shellman	C. of Ga.	379?
Sibley	G. S. & F.	440
Sisters Ferry, Effingham Co. low water	U. S. A. Eng.	20.03
Slover	U. S. G. S.	92
Smithville	C. of Ga.	332
Sofkee	G. S. & F.	370
Soperton	Aneroid	308
Southover Junction	A. C. L.	20
Sparks	G. S. & F.	241
Sparta	Ga. R. R.	557
Springfield	U. S. G. S.	80
Statenville	A. C. L.	152
Statesboro	U S. G. S.	218-250
Stapleton	U. S. G. S.	440
Sterling	U S. G. S.	21
Stillmore	Aneroid	275
Stillwell, Effingham Co.	S A. L.	69
Stillson	U S. G. S.	105
Stockton	A. C. L.	187
Sulphur Springs	U. S. G. S.	300
Sumner	A. C. L.	373
Sunhill	C. of Ga.	362

Altitudes in coastal plain—continued.

TOWN	Authority	Elevation, Feet
Surrency	U. S. G. S.	187
Swainsboro	Aneroid	318
Swift Creek	M. D. & S.	324?
Sycamore	G. S. & F.	415
Sylvania	U. S. G. S.	238
Sylvester	A. C. L.	370?
Talbotton	U. S. G. S.	726
Tarboro	"	12
Tarrytown	Aneroid	310
Tennille	C. of Ga.	469
Thalman	U. S. G. S.	20
Thelma	G. S. & F.	158
Thomas	C. of Ga.	285
Thomasville	A. C. L.	250
Thomson	Ga. R. R.	503
Tifton	A. C. L.	370
Tivola	G. S. & F.	300
Toomsboro	U. S. G. S.	236
Towns	"	128
Troy	"	520
Trudie	"	56
Tusculum (Brewer)	"	122
Tyty	A. C. L.	332
Unadilla	G. S. & F.	412
Undine	U. S. G. S.	155
Upatoi	"	418
Uptonville	U. S. G. S.	85
Uvalda	Aneroid	185
Valambrosa	M. D. & S.	258?
Valdosta	A. C. L.	215
Valona, McIntosh Co.	Weather Bureau	10
Vidalia	Aneroid	300
Vidette	U. S. G. S.	350
Vienna	G. S. & F.	350
Wadley	C. of Ga.	234
Wainwright (Uptonville Sta.)	U. S. G. S.	85
Walden	C. of Ga.	390
Walthourville	A. C. L.	95
Waresboro	"	121
Warrenton	Ga. R. R.	500
Warthen	Aneroid	490
Waverly	U. S. G. S.	20
Waycross	A. C. L.	140
Waynesboro	U. S. G. S.	261
Waynesville	"	50
Ways	A. C. L.	18

Altitudes in coastal plain—continued.

TOWN	Authority	Elevation, Feet
Wellston	G. S. & F.	315
Wenona	"	348
West Green	Aneroid	255
Westlake	U. S. G. S.	235
Weston	S. A. L.	528
Westover	U. S. G. S.	142
Wheaton, Appling Co.	"	201
Whigham	A. C. L.	265
Whiteoak	U. S. G. S.	15
Willets	"	250
Willie	"	87
Willis (Gallemore)	M. D. & S.	394?
Wilcox	Sou. Ry.	116
Willacoochee	A. C. L.	247
Wilingham	"	319
Winchester	C. of Ga.	463
Woodbine	U. S. G. S.	14
Worth	G. S. & F.	415
Wray	Rough Est.	290
Wrens	U. S. G. S.	423
Wrightsville	Aneroid	335
Zenith	Aneroid	567

The abbreviations used are,

A. B. & A.—Atlanta, Birmingham & Atlantic Railroad.
A. C. L.—Atlantic Coast Line Railroad.
C. of Ga.—Central of Georgia Railroad.
Ga. R. R.—Georgia Railroad.
G. & F.—Georgia and Florida Railroad.
G. F. & A.—Georgia, Florida & Alabama Railroad.
G. S. & F.—Georgia Southern & Florida Railroad.
L. & N.—Louisville & Nashville Railroad
M. D. & S.—Macon Dublin & Savannah Railroad.
S. A. L.—Seaboard Air Line Railroad.
S. & S.—Savannah & Southern Railroad.
Sou. Ry.—Southern Railway.
U. S. A. Eng.—United States Army Engineers.
U. S. G. S.—United States Geological Survey.

RIVER ALTITUDES IN GEORGIA COASTAL PLAIN

(Distance by air line.)

Elevations of normal water surface of Altamaha River

		Feet above sea level
Mouth of Penholoway Creek	U. S. A. Eng.	24
Doctortown	U. S. A. Eng.	29
Mouth of Ohoopee River	U. S. A. Eng.	50
Mouth of Cobbs Creek	U. S. A. Eng.	69
Junction Oconee and Ocmulgee rivers	U. S. A. Eng.	83

Elevations of normal water surface of Chattahoochee River

		Feet above sea level
Flint River, junction with Chattahoochee River	U. S. A. Eng.	45.0
Mouth of Sowhatchee Creek	U. S. A. Eng.	65.3
Mouth of Cohelee Creek	U. S. A. Eng.	76.0
Mouth of Colomokee Creek	U. S. A. Eng.	90.8
Fort Gaines	U. S. A. Eng.	96.7
Mouth of Pataula Creek	U. S. A. Eng.	105.5
Georgetown	U. S. A. Eng.	118.0
Mouth of Hannahatchee Creek	U. S. A. Eng.	142.7
Mouth of Hichitee Creek	U. S. A. Eng.	152.0
Mouth of Upatoi Creek	U. S. A. Eng.	174.5
Columbus Wharf	U. S. A. Eng.	185.5

Elevations of normal water surface of Flint River

		Feet above sea level
Flint-Chattahoochee River junction	Calculated	52
Bainbridge	G. F. & A.	68
Newton	Calculated	95
Albany	A. C. L.	127
Montezuma	Aneroid	265
Fall line	Ga. Bull. No. 16, p 20	327

Elevations of normal water surfaee of Ocmulgee River

		Feet above sea level
Junction Oconee and Ocmulgee rivers	U. S. A. Eng.	83
Lumber City	U. S. A. Eng.	85
Barrows Bluff	U. S. A. Eng.	126
One mile below Coffee-Ben Hill County line	U. S. A. Eng.	131
Ben Hill -Wilcox County line	U. S. A. Eng.	151
Abbeville	U. S. A. Eng.	169
Mouth of Mosquito Creek	U. S. A. Eng.	193
Mouth of Limestone Creek	U. S. A. Eng.	196
Hawkinsville	U. S. A. Eng.	200
Macon	U. S. A. Eng.	279

Elevations of normal water surfaee of Oconee River

		Feet above sea level
Junction Oconee and Ocmulgee rivers	U. S. A. Eng.	83
Mouth Ochwalkee Creek	U. S. A. Eng.	110
Mouth Pues Creek	U. S. A. Eng.	155
Dublin	U. S. A. Eng.	161
Mouth Buffalo Creek	U. S. A. Eng.	193
Milledgeville	U. S. A. Eng.	241

Elevations of normal water surface of Ogeechee River

		Feet above sea level
Cones Bridge, opposite Pineora	U. S. G.S.	40
Point 1 mile above Taylor's Landing, 1½ miles below point due east of Brooklet	U. S. G.S.	50
Mouth Mill Cr., due east of Leland	U. S. G. S.	60
Point 1 mile above mouth Ogeechee Creek	U. S. G. S.	70
Mouth Buck Creek	U. S. G. S.	80
Point opposite Dover	U. S. G. S.	90
Lone Bridge, opposite Ogeechee	U. S. G. S.	100
Point due south of Rocky Ford	U. S. G. S.	110
Point 1 mile below Scarboro	U. S. G. S.	120
Point due Southwest of Paramore Hill Sta	U. S. G. S.	130
Point 1½ miles above Millen bridge	U. S. G. S.	140
Midville	U. S. G. S.	168

Elevations of normal water surface of St. Marys River

		Feet above sea level
Point 7 miles north of St. George	U. S. G. S.	10
At St. George	U. S. G. S.	21
Point 2¾ miles due north of point on river due east of Stokesville	U. S. G. S.	30
Point 2½ miles southeast of Stokesville at point where river turns north	U. S. G. S.	40
Point 6½ miles north of Glen St. Mary Fla.	U. S. G. S.	50
Point 4½ miles south of Moniac	U. S. G. S.	80
Point 1½ miles south of Moniac	U. S. G. S.	90
Point 1 mile north of Moniac	U. S. G. S.	100

Elevations of normal water surface of Savannah River

		Feet above sea level
Ebenezer Creek	U. S. A. Eng.	14
Sisters Ferry, opposite Clyo	U. S. A. Eng.	20
Brier Creek	U. S. A. Eng.	46
Brier Creek estimated	U. S. G. S.	
Cohens Bluff Ldg., S. C. 4 miles above mouth Brier Creek	U. S. G. S.	50
Black Creek Landing	U. S. A. Eng.	43
Burton's Ferry, due east of Millhaven	U. S. G. S.	60
Point 2 miles below Burke-Screven line	U. S. G. S.	70
Burke-Screven County line, estimated	U. S. G. S.	74
Steel Creek Ldg., S. C. 6 miles above Burke-Screven line	U. S. G. S.	80
Shell Bluff Ldg., estimated	U. S. G. S.	92
Shell Bluff Ldg.	U. S. A. Eng.	87
Mouth of McBean Creek, estimated	U. S. G. S.	95
Mouth of McBean Creek	U. S. A. Eng.	87
Little Spirit Creek	U. S. G. S.	100
Augusta, estimated	U. S. G. S.	109
Augusta	U. S. A. Eng.	103
Point 1½ miles above S. A. L. Crossing near Clyo	U. S. G. S.	20
Hudson's Ferry, 2 miles above Screven-Effingham line	U. S. G. S.	30
Poor Robin Landg., due east of point 3¼ miles south of Sylvania	U. S. G. S.	40

Elevations of normal water surface of Satilla River

		Feet above sea level
Point 2 miles above Wayne-Camden County line	U. S. G. S.	10
Point between Luluton and Atkinson at A. C. L. bridge	U. S. G. S.	19
Trudie	U. S. G. S.	31
Point opposite Waycross, at A. C. L. Crossing	U. S. G. S.	71.8

Elevations of normal water surface of Little Satilla Fork

		Feet above sea level
Satilla	A. C. L.	71

Elevations of normal water surface of Withlacoochee River

		Feet above sea level
Mineola	G. S. & F.	124

INDEX

INDEX

INDEX